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WALDO LAKE DAM MA 004.. (U) CORPS OF ENGINEERS WALTHAM
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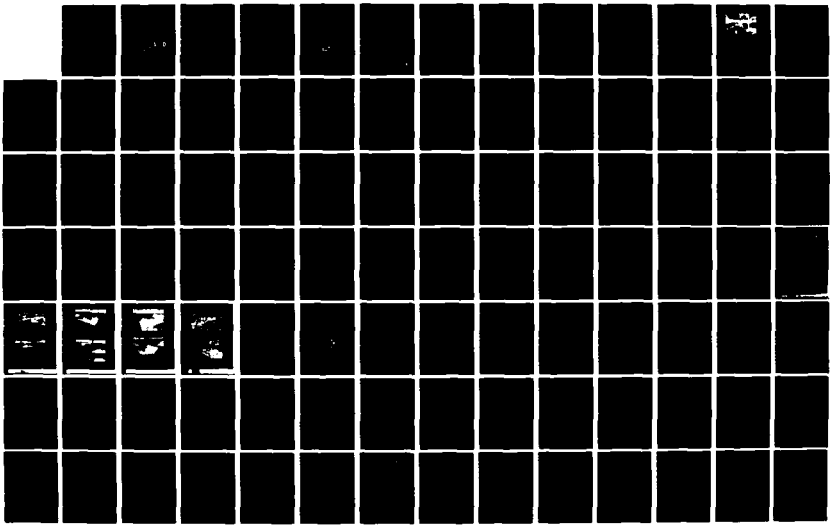

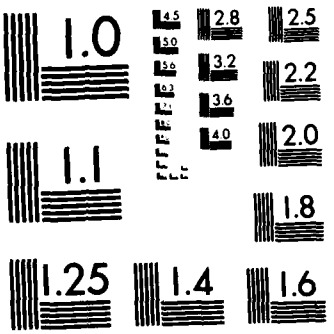

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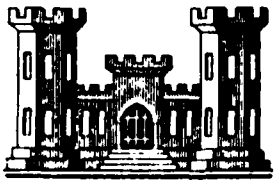
TAUNTON RIVER BASIN
BROCKTON, MASSACHUSETTS

WALDO LAKE DAM
MA 00426

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

MAY 1979

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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4. TITLE (and Subtitle) Waldo Lake Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT 6. PERFORMING ORG. REPORT NUMBER
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18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Taunton River Basin
Brockton, Massachusetts

Beaver Brook

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Waldo Lake is an earth dam about 400 ft. long and 17 ft. high. The facility is in fair condition. The spillway capacity is limited and the left dike is essentially unprotected against erosion during any overtopping flow. The size classification is small and the hazard potential is high, the spillway test flood selected is the Probable Maximum Flood.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:
NEDED

SEP 17 1979

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:

I am forwarding to you a copy of the Waldo Lake Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. In addition, a copy of the report has also been furnished the owner, City of Brockton, Brockton, Massachusetts 02401.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for your cooperation in carrying out this program.

Sincerely yours,

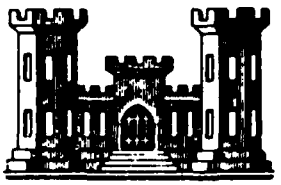
MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

TAUNTON RIVER BASIN
BROCKTON, MASSACHUSETTS

WALDO LAKE DAM
MA 00426

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



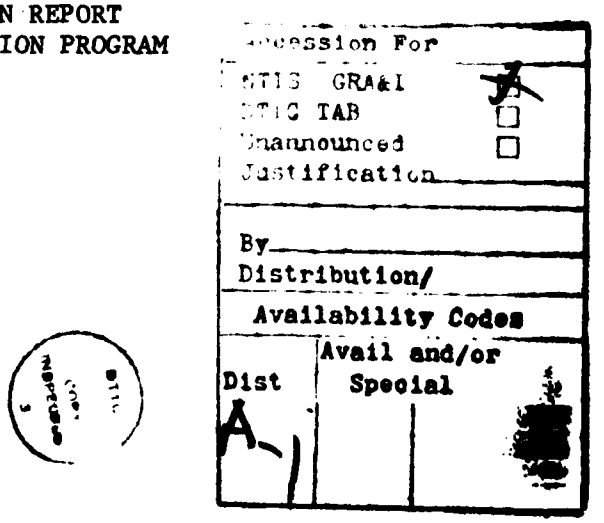
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

MAY 1979

WALDO LAKE DAM
MA 00426

TAUNTON RIVER BASIN
BROCKTON, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Identification No. : MA 00426
Name of Dam: WALDO LAKE DAM
Town: BROCKTON
County and State: PLYMOUTH COUNTY, MA
Stream: BEAVER BROOK
Date of Inspection: 4 OCTOBER 1978 (supplemental visit on 23 March 1979)

BRIEF ASSESSMENT

Waldo Lake Dam is an earth dam approximately 400 feet long and 17 feet high. A park roadway forms the crest of the dam. A 175 foot long by 14 foot high semi-circular spillway embankment is appended to and in front of the main dam. It contains two reservoir drains, a principal spillway and an overflow spillway. Flow from the spillways passes through a stone and concrete culvert under the dam. A dike with a gravel road and unpaved parking area as its crest is located to the left of the dam.

The facility is in fair condition. The spillway capacity is limited and the left dike, the critical feature, is essentially unprotected against erosion during any overtopping flow. The spillway complex is in need of repairs.

Based on the size classification, small, and hazard classification, high, in accordance with the Corps of Engineers guidelines, the spillway test flood selected is the Probable Maximum Flood (PMF). Hydraulic analysis indicates the peak test flood outflow would be 3560 cfs while the total maximum capacity of the spillways with the pond water surface at the crest of the dam is estimated to be approximately 800 cfs or 22 percent of the test flood. The test flood selected would result in an overtopping of the dam by 0.6 feet and dike by 2.0 feet at peak discharge.

Investigation of the dike erosion protection, spillway hydraulic adequacy, seismic stability of the dam and the structural adequacy of the spillway entrance structures are recommended. Remedial measures recommended include the removal of brush and trees, the establishment of protection to various embankments, the repair and maintenance procedure and the establishment of an emergency preparedness plan and warning system. The remedial measures and investigations should be performed by the Owner within one year after receipt of this report.

Camp Dresser & McKee Inc.

Roger H. Wood

Roger H. Wood
Vice President

This Phase I Inspection Report on Waldo Lake Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

Joseph W. Finegan

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

Joseph A. McElroy

JOSEPH A. MCELROY, MEMBER
Foundation & Materials Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, CHAIRMAN
Chief, Structural Section
Design Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

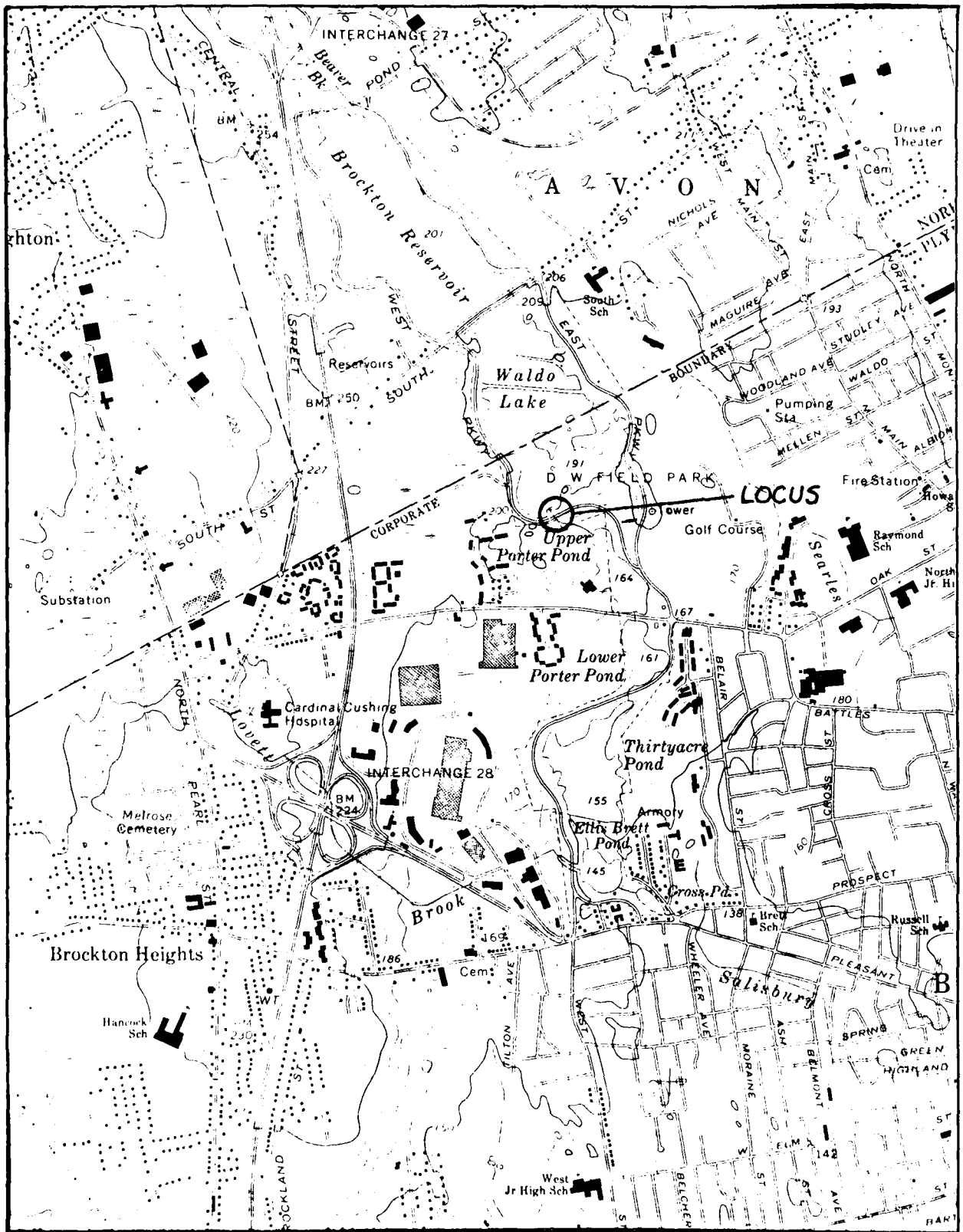
Phase I Investigations are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the test flood is based on the estimated "probable maximum flood" for the region (greatest reasonably possible storm runoff), or a fraction thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

APPENDIXES

1. Overview of upstream face of dam and spillway from dike.



DAM WALDO LAKE DAM

IDENTIFICATION NO. MA 00426

LOCATION MAP
USGS QUADRANGLE

Brockton, Massachusetts

APPROX. SCALE: 1" = 2000'

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
WALDO LAKE DAM
MA 00426

SECION 1: PROJECT INFORMATION

1.1 General

a. Authority - Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region.

Camp Dresser & McKee Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued to Camp Dresser & McKee Inc. under letters of 12 July 1978 and 23 October 1978 from Colonel John P. Chandler, Corps of Engineers. Contract No. DACW 33-78-C-0054 has been assigned by the Corps of Engineers for this work. Haley and Aldrich, Inc. has been retained by Camp Dresser & McKee Inc. for the soils and geological portions of the work.

b. Purpose - The primary purpose of the investigation is to:

(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.

(3) Update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location - Waldo Lake Dam is located on Beaver Brook, in the City of Brockton, Massachusetts, as shown on the report's Location Map. It is one of seven surface bodies of water in the D.W. Field Park (a recreational facility which serves the City). The main dam and spillways are located on the southern portion of Waldo Lake adjacent to D.W. Field West Parkway. The parkway itself forms the dam with the spillway and gate structures located on a semi-circular embankment just north of the parkway.

b. Description of Dam and Appurtenances - Waldo Lake Dam consists of a broad, curved embankment with an appended lower earth spillway embankment, semi-circular in shape, on the upstream side. There are four water control structures as shown on page C-1 in the lower embankment. From left to right, looking downstream, the water controls are: 1) principal spillway with stoplogs and twin 24-in. diameter concrete pipes, 2) a gated 36-in. reservoir drain pipe, 3) an ungated broadcrested overflow spillway, and 4) a gated 36-in. diameter reservoir drain pipe. The principal spillway consists of 7.25-foot by 6.6-foot concrete structure with provisions for 3 feet of stoplogs. The ungated overflow spillway is 16 feet wide with sidewalls of 3 feet. The exposed face of the sidewalls are mortared cobbles. The four structures discharge to a roughly circular paved stilling basin which drains beneath the roadway embankment through twin 3.5-foot by 5-foot openings into a concrete box culvert and then into a natural channel of the downstream side of the embankment. However, the culvert's size beneath the embankment is 8 feet by 6 feet. The culvert entrance will act as a hydraulic control during flooding events which overtop the spillway embankment.

The 400 ft. long curved embankment (a portion of D.W. Field West Parkway) has a maximum height of approximately 17 ft above the ground at the embankment toe. The crest of the embankment, which serves as a roadway, is pitched to drain towards the lake. It varies in width from about 41 ft above the culvert to 45 ft and greater near the abutments. The high edge of the embankment crest is approximately 6 ft above the overflow spillway crest. The downstream slope is generally about 1 vertical to 2 horizontal (1V to 2H) and covered with a bed of cobbles. However, these cobbles are not permanently fixed to the slope. The upstream slope is slightly stepped, averaging somewhat flatter than 1V to 3H. Stone paving is provided on the upstream slope to 4 to 5 ft above the spillway crest.

The 175 ft long semi-circular spillway embankment is approximately 14 ft in height, measured from the bottom grade of the pool at the downstream toe. The crest of this embankment is, therefore, about 3 ft above the overflow spillway crest. Its width at the top varies from 6 to 8 ft. For the most part, the top of the embankment is bare with small patches of short grass. The upstream slope is similar to that of the dam embankment. The downstream slope, approximately 1V to 1.5H overall, is terraced with 3 ft wide horizontal berms retained by lines of boulders. The terraces are landscaped with evergreen shrubs and other plants.

There is an approximately 7.6 ft high gravel fill dike located to the left of the dam, which has its crest approximately 4.5 ft above the overflow spillway crest, or about 1.4 ft lower than the main dam embankment. The top of the separate dike is 40 ft wide and 290 ft in length. The irregular downstream and upstream slopes are estimated to be 1V to 2H and 1V to 3H, respectively.

c. Size Classification - Waldo Lake Dam has a maximum height of approximately 17 feet and a maximum storage of 884 acre-feet. According to guidelines established by the Corps of Engineers, the dam is classified in the small category.

d. Hazard Classification - Dam Failure Analysis (Section 5.1e) indicates severe flooding potential to the majority of structures downstream of Cross Pond and their connecting streets. In addition, a portion of the D.W. Field West Parkway would be overtopped as well as the Upper and Lower Porter Pond Dams, Ellis Brett and Cross Pond Dams and Thirty Acre Pond Dam. Consequently, this dam is classified as having a "high" hazard potential.

e. Ownership - The dam and lake is owned by the City of Brockton. The owner is represented by Mr. John J. Dorgan, Superintendent of Parks, City Hall, Brockton, MA 02401 (phone: 617/580-1100).

f. Operator - Mr. John J. Dorgan is assigned responsibility for operation of the dam.

g. Purpose of Dam - Waldo Lake was constructed solely for recreational purposes.

h. Design and Construction History - Waldo Lake Dam was designed by Mr. Fred Stetson of the Brockton Engineering Department. As with the other ponds in the park, Waldo Lake was constructed for aesthetic purposes. The entire park scheme is the result of years of work by Mr. Daniel Waldo Field who acquired the majority of the land between 1925 and 1935. The end result is a park where the citizens of Brockton and neighboring communities may partake in both passive and active forms of recreation.

   Construction of the project was by Powers Brothers of Brockton, Massachusetts, and occurred in 1936. The dam is operated and maintained by the City of Brockton's Park Department.

i. Normal Operational Procedure - There is no defined operational procedure for the dam.

   Stoplogs are added or removed at the discretion of members of the Park Department.

1.3 Pertinent Data

Elevations given in this report are on National Geodetic Vertical Datum (NGVD) formerly referred to as Mean Sea Level. They are based on a survey by Camp Dresser & McKee for a 1968 Master Plan Report.

a. Drainage Area - The drainage area to Waldo Lake is approximately 3.25 square miles (2,080 acres). The pond surface itself comprises 3.7 percent (77 acres) of the total drainage area. The watershed's topography is primarily densely forested rolling terrain with large portions of wetlands. Beaver Brook rises in a marshland approximately 2.0 miles north of Waldo Lake in the neighboring Town of Stoughton. It flows southwest via culverts under Route 24, joins with an unnamed brook, and flows for approximately 0.6 miles before entering the Brockton Reservoir system. The Reservoir's outlet is a 27 foot long spillway which leads to twin stone arch culverts under South Street. The flows are conveyed via an estimated 500 foot long natural channel into Waldo Lake. After leaving Waldo Lake via a spillway system, it flows through Upper and Lower Porter Ponds, Thirty Acre Pond, Ellis Brett Pond, and Cross Pond. These ponds are connected by natural channels and have spillway structures as their regulating outlets. After leaving Cross Pond, it enters Salisbury Brook and is conveyed by a series of culverts and man-made channels through the center of the City of Brockton. Salisbury Brook joins with Trout Brook at the south easterly section of the city to form the Salisbury Plain River.

b. Discharge at Damsite - Three notable floods have occurred in the watershed since the construction of Waldo Lake Dam: September 21, 1938; August 19-21, 1955; and March 17, 1968. The total storm rainfall for these floods were respectively: 5 inches in 5 days, 13.76 inches in 72 hours, and 6.33 inches in 48 hours. However, there are no records of the reservoir's water surface elevation during these events.

(1) Outlet works size----------Two 36-in. concrete pipes with stoplog weir

(2) Maximum known flood at damsite: August 18-21, 1955

(3) Ungated spillway capacity at top of dam
798 cfs @ 197.5 elev.

(4) Ungated spillway capacity at test flood elevation
818 cfs @ 198.1 elev.

(5) Gated spillway capacity at normal pool elevation-------N/A

(6) Gated spillway capacity at test flood elevation--------N/A

(7) Total spillway capacity at test flood elevation
818 cfs @ 198.1 elev.

(8) Total project discharge at test flood elevation
3560 cfs @ 198.1 elev.

c. Elevation (ft. above NGVD)

(1) Streambed at centerline of dam----------180.5

(2) Test flood tailwater----------Unknown

(3) Upstream portal invert diversion tunnel----------None

(4) Recreation pool----------189.7

(5) Full flood control pool----------N/A

(6) Spillway crest----------Principal: 186.7 (min)
Overflow: 191.6

(7) Design surcharge (Original Design)----------Unknown

(8) Top of dam----------197.5
Left dike crest----------196.1

(9) Test flood design surcharge----------198.1

d. Reservoir

(1) Length of test flood pool----------0.54 miles

(2) Length of recreation pool----------0.53 miles

(3) Length of flood control pool----------N/A

e. Storage (acre-feet)

(1) Recreation pool----------227

(2) Flood control pool----------N/A

(3) Spillway crest pool----------Principal: 165 (min)
Overflow: 285

(4) Top of dam----------884

(5) Test flood pool----------961

f. Reservoir Surface (acres)

(1) Recreation pool----------74

(2) Flood-control pool----------N/A

(3) Spillway crest----------Principal: 74 (min)
Overflow: 80

(4) Test flood pool----------129

(5) Top of dam----------126

g. Embankments

	Dam Embankment	Spillway Embankment	Dike Embankment
(1) Type	Earth (curved and pitched to drain towards lake)	Earth (semi-circular shape)	Earth
(2) Length (Approx)	400 ft	175 ft	290 ft
(3) Height (Approx)	17 ft	13 ft	7.5 ft
(4) Top width & elev.	41 to over 45 ft at elev. 197.5	6 to 8 ft at elev. 194.6	40 ft at elev. 196.1
(5) Side slopes (Approx)	3H to 4H to to 1V U/S, 2H to 1V D/S	3H to 4H to 1V U/S, 1.5H to 1V D/S	2H to 1V U/S, 3H to 1V D/S
(6) Zoning	Unknown	Unknown	Unknown
(7) Impervious Core	Unknown	Unknown	Unknown
(8) Cutoff	Unknown	Unknown	Unknown
(9) Grout Curtain	Probably none	Probably none	Probably none

h. Diversion and Regulating Tunnel----------None

i. Spillway

	Principal	Overflow
(1) Type	Sharp-crested	Broad-crested
(2) Length of weir	7.25 ft	16 ft
(3) Crest elevation	186.7 (min)	191.6
(4) Gates	None	None
(5) U/S Channel	1V to 4H	1V to 4H
(6) D/S Channel	1V to 2H	1V to 2H

j. Regulating Outlets - There are three areas at which control can be exercised on the lake's water surface. The first, called principal spillway in this report, has a stoplog entrance with two 36-inch concrete pipes as its discharge. The crest elevation range for the stoplogs is estimated to be elevation 186.7 to 189.7. The other two areas of control are the left and right reservoir drains. Each is a 36-inch pipe with a manually operated valve at the inlet end. Due to the absence of plans and the valves being buried in cobbles and silt, the invert elevations cannot be estimated.

SECTION 2: ENGINEERING DATA

2.1 Design Records - No design records for this dam are available.

2.2 Construction Records - No construction records for this dam are available.

2.3 Operation Records - No operation records other than inspection reports on the facility were located.

2.4 Evaluation

a. Availability - Biennial inspection reports described above are available at the Plymouth County Engineering Department, Plymouth, MA.

b. Validity - It was found that a large amount of discrepancies in measurements existed between the sketches of the structures that accompany the prior inspection reports and measurements made during the field inspection.

c. Adequacy - The available data, in combination with the visual evaluation described in the following section is adequate for the purposes of the Phase I investigation.

SECTION 3: VISUAL EXAMINATION

3.1 Findings

a. General - The Phase I visual examination of Waldo Lake Dam was conducted on 4 October 1978. A supplemental inspection was made at the roadway portion of the dam and the dike on 23 March 1979.

In general, the dam was in good condition. However, the facility is considered to be only in fair condition, due to the limited spillway capacity and the unprotected condition of the left dike. The spillway complex is in need of repairs although it is noted that if the spillway failed, the water would still be impounded by the main dam and the outflow would occur through the ungated outlet culvert.

Visual inspection checklist for the site visit are included in Appendix A and selected photographs are given in Appendix C.

b. Dam - The earth embankment and outlet culvert are generally in good condition. There was no visual evidence of settlement, lateral movement, significant seepage, structural deterioration or other serious defects which would require immediate remedial action.

The following specific items were noted:

1. The upstream slope of the roadway embankment is relatively flat and generally protected by broken rock, cobbles and boulders to a level approximately 4 to 5 ft above the spillway crest. The slope protection has been locally displaced in some areas at and below the apparent high water line, as shown in Photos Nos. 1 and 2.

2. The upstream slope and crest of the dam embankments above the slope protection are generally mowed and clear of brush and trees. However, foot traffic has caused many bare areas to develop, especially near the spillway embankment, as shown in Photos 2 and 4.

3. The pavement on the crest of the roadway embankment is in good condition, as shown in Photo 2. There are evergreen trees from 3 to 9-in. in diameter along the edge of the pavement at the top of the downstream slope. Cobbles and boulders cover most the downstream slope, which also has a small amount of scattered brush and numerous trees along the bottom of the slope, as shown in Photo 3. Some local wetness was noted just below the downstream toe, but no active seepage was observed.

c. Appurtenant Structures - The spillway semi-circular embankment and dike are in fair condition. There was no visual evidence of settlement, lateral movement, significant seepage or other serious defects which would require immediate remedial action. The structure on the spillway embankment vary in condition. While some of these are in poor condition, no serious defect was observed which would require immediate remedial action.

The following specific items for the spillway were noted:

1. The upstream slope protection has been locally displaced in some areas at or below the apparent high water line as shown in Photos 4 through 8.

2. Foot traffic has caused many bare areas to develop as shown in Photos 4 through 8.

3. The embankment crest is locally eroded up to 6" below the top of the stone masonry walls to the left and right of the overflow spillway, and from 8 to 18 inches below the top of concrete behind the headwalls of the other structures as shown in Photo 7.

4. The downstream slope of the embankment is heavily planted with junipers and other shrubs that hinder visual examination, as shown in Photo 4. In some areas, the boulders retain the terraces which have been dislodged and have rolled down the slope. A small portion of the overall downstream slope is bare and eroding. No seepage was noted around the perimeter of the pool at the toe, although prior inspection reports indicate that minor seepage has been observed on the slope in the past.

5. The headwalls of the principal spillway had some erosion of concrete present as shown in Photo 5.

6. The headwalls of the left reservoir drain and the right reservoir drain have significant deterioration especially at the elevation of normal water level as shown in Photos 6 and 8.

7. The inlets of the principal spillway and the reservoir drains contain silted materials, cobbles and debris. The valves at the reservoir drains appear not to have received recent maintenance.

8. The upstream ends of the overflow spillway sidewalls have deteriorated.

9. Undercutting is present at the pipe outlets of the principal spillway and the ornamental bushes interfere with the discharge of the left reservoir drain as indicated in Photo 4.

10. Trees are present in the center of the discharge channel immediately downstream of the culvert through the dam as shown in Photo 10. It should be noted that the photograph distorts the stones present in the channel.

The following specific item for the dike was noted:

1. The separate low dike to the left of the main dam has an unprotected and rutted gravel surface that is used for parking, along with a regular slope partially covered with trees, brushes and rocks, as shown in Photo 11.

d. Reservoir Area - The reservoir area is divided by a water main embankment which extends from east to west across the lake. Underneath the water main near the westerly end of the fill is a 15 foot wide by 6.4 foot high rectangular concrete culvert connecting the two portions of the lake. The area around Waldo Lake is heavily forrested with no development.

e. Downstream Channel - Beaver Brook conveys the discharge from the outlet works of the dam to the Salisbury Brook, a distance of 1.5 miles. Along this course, five dams and hydraulic control structures, five ponds, and two culverts are located.

3.2 Evaluation

The embankments at Waldo Lake Dam appear to be performing satisfactorily at the present time. However, dislodged stone riprap on the upstream slope and low, bare areas on the spillway embankment are deficiencies that could permit future erosion of the embankments at higher than normal lake levels. The shrubbery on the landscaped downstream slope of the spillway embankment and the pool of water at the toe may have obscured seepage. The trees along the downstream side of the broad dam embankment crest are not considered to be a hazard to the safety of the dam. The gravel surface of the relatively low dike to the left of the dam would be susceptible to erosion in the event of overtopping. The inlet structures at the reservoir drains are in poor condition and should be replaced. The inlets at the principal and overflow spillways require repair. The outlets at the principal spillway and left reservoir drain need attention.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedure - There is no defined operation and maintenance procedure manual for the dam.

4.2 Maintenance of Dam - The general appearance of the project indicates that the dam does receive limited maintenance, probably on the basis of demand. The grass on the embankments is mowed, but bare and eroded areas have been allowed to develop, probably due to recreational use.

4.3 Maintenance of Operating Facilities - Maintenance of the operating facilities is performed at the discretion of the Superintendent of Parks for the City of Brockton, MA. It appears that the stoplogs for the principal spillway weir are being maintained. However, the two cast-iron reservoir drain gates are currently silted in and could not be readily operated in the event of an emergency.

4.4 Description of any Warning System in Effect - There is no established warning system or emergency preparedness plan in effect for this structure.

4.5 Evaluation - In general, the maintenance of this dam is being attended to. However, there were two areas observed which need attention: the lack of ground cover of the dam's embankment at some spots and the inoperability of the reservoir drain gates.

A written Operation and Maintenance Manual should be established for this facility as well as a formal warning system and emergency preparedness plan. The Owner should institute a program of annual technical inspections.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. General - Waldo Lake Dam is an earth embankment which comprises a portion of D.W. Field West Parkway. It is basically a high surcharge - low spillage project with limited outlet capacity. The level of the lake is kept fairly constant by maintaining a constant height of flashboards in the regulating spillway. The discharge capacity of both the principal and overflow spillways is a total of 630 cfs to elevation 194.6 (top of the semi-circular spillway embankment). After this point, the twin box culvert which conveys flows from the stilling basin under the dam, does control the flow. At elevation 197.5 (top of dam), the discharge capacity of this culvert is approximately 800 cfs. The width of the dam varies between 40 and 45 feet with the greatest width at the outlet structure.

b. Design Data - No construction or record plans were found for Waldo Lake Dam. No original hydraulic nor hydrologic design data was found. However, a report entitled "Master Plan Study for D.W. Field Park" submitted to the Brockton Park Commission in April 1968 by Camp Dresser & McKee Inc. suggested that the spillway system at Waldo Lake be reconstructed to pass the flows generated by a six-hour rainfall of 13 inches with the still surface of the ponded water at least 3 feet below the top of the dam. This criteria was established by the Soil Conservation Service of the United States Department of Agriculture for a Class B structure. However, it appears from the visual inspection that the modifications suggested in the aforementioned report were not made.

c. Experience Data - No records of past floods are available for the dam site.

d. Visual Observations - A visual inspection was made of the portions of the outlet works that are accessible and not submerged which includes the principal and outlet spillways, the gated 36-inch concrete pipes , and the twin box culvert. All, except for the gated outlet pipes, were observed to be in good condition. The Owner indicated that the two cast-iron gates are currently silted in and inoperable. However, the pipes themselves did not appear to be blocked.

e. Test Flood Analysis - Based upon the Corps of Engineers guidelines, the recommended test flood for the size (samll) and hazard potential (high) is within the range of 1/2 PMF to a full PMF (Probable Maximum Flood). The dam was evaluated for the full PMF, due to the downstream development. The "SCS-TP-149, Method for Estimating Volume and Rate of Runoff in Small Watersheds," was used as a guide for determining the inflow hydrograph

into Waldo Lake for the probable maximum flood (24 inches of rainfall in 6 hours). The peak inflow was calculated to be 4,400 cfs. This flow was routed through the two spillway outlets at the dam using the method for flood routing presented in "Water Supply and Wastewater Disposal" by Fair and Geyer. The lake's inflow as reduced to a maximum outflow of 3,560 cfs at a water surface of 198.1 feet. At this stage, the dam will be overtopped by approximately 0.6 feet and the dike will be overtopped by approximately 2.0 feet. The crest of the dam is paved and has a width of over 40 feet and thus could take some overtopping provided that the dike were corrected. The portion of the test flood which discharges through the spillway is 630 cfs or approximately 18 percent of the test flood.

f. Dam Failure Analysis - Dam failure analysis was performed to determine the magnitude of downstream hazards. A peak failure outflow of approximately 4,710 cfs was estimated based on a 40 foot breach width of the dam embankment (the section adjacent to and including the outlet culvert). The analysis indicates that this flow would result in the overtopping of Upper Porter Pond Dam (Oak Street), Lower Porter Pond Dam (D.W. Field Parkway, Thirty Acre Pond Dam, Ellis Brett Pond Dam, and Cross Pond Dam (Elmwood Avenue). Moderate flooding of the homes to the west and east of Cross Pond as well as to the homes adjacent to the Salisbury Brook on Prospect and Pleasant Street, and from Wheeler Avenue to Arlington Street. However, the overtopping of these downstream dams would greatly increase the possibility of their failing. The failure of any one of these downstream structures, especially Thirty Acre Pond Dam, would effectively multiply the degree of downstream flooding and consequently economic losses incurred by damage to residential and commercial structures, utilities and roads and the potential for loss of life.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations - There was no visible evidence of dam, dike or spillway embankment instability during the site examination on 4 October 1978 and the supplemental site examination on 23 March 1979. Vegetation on the downstream slope and the pool of water at the toe of the spillway embankment may have concealed seepage (which has been observed in the past). However, instability of the spillway embankment would not necessarily risk dam failure unless it resulted in a blockage of the twin box culvert under the main roadway embankment.

b. Design and Construction Data - There are neither design drawings nor construction data which would show the embankment cross-section and the physical properties of the materials used to construct the embankments. Therefore, theoretical analyses of embankment stability are not possible.

Both the dam roadway embankment and the separate dike are relatively wide to accomodate vehicular traffic; side slopes are generally equal to or flatter than is the usual practice for New England dams. In the absence of significant seepage these wide embankments would be expected to provide adequate stability under static loading conditions.

c. Operating Records - There is no instrumentation installed at the dam site or records of performance under prior maximum loading conditions to aid in the stability evaluation.

d. Post-Construction Changes - The descriptions of the dam contained in available prior inspection reports have revealed no major post-construction changes to the embankments that might influence the safety of the dam. It was noted that portions of the upstream spillway embankment riprap have recently been covered by cement concrete. This remedial measure tends to improve the embankment slope protection, and thus is desirable.

e. Seismic Stability - Waldo Lake Dam is located in Seismic Zone 3. Pertinent data needed for theoretical seismic stability analyses of the embankments are not available. Therefore, the stability of the embankments during an earthquake is unknown. It should be noted that a failure of spillway embankment alone would probably not be a catastrophic event, since the flow of water from the lake would then be controlled by the culvert through the dam embankment.

SECTION 7: ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition - The visual examination of Waldo Lake Dam did not reveal any evidence of failure or conditions which would warrant urgent remedial treatment. Due to the noted deficiencies, the overall condition of the spillway and dike embankments are considered to be fair while the main dam or roadway is considered to be in good condition.

b. Adequacy of Information - Since there was a lack of engineering data available, nearly all of the information for the Phase I investigation had to be obtained from visual examination and limited measurements at the site. This information has been sufficient for the purpose of this investigation, but it does not permit detailed evaluation of seismic stability.

c. Urgency - The recommended additional investigation and remedial measures outlined in Sections 7.2 and 7.3, respectively, should be undertaken within one year after receipt of this report by the Owner.

d. Need for Additional Investigations - Additional investigations should be performed by the Owner as outlined in the following section.

7.2 Recommendations

It is recommended that the owner engage a registered professional engineer to undertake the following investigations and implement corrective action as required:

1. An engineering investigation for the reconstruction or replacement of the deteriorated concrete entrance structures at the left and right reservoir drains. The work should include an investigation of the condition of the inlet valves, due to their prolonged period of inactivity and the valve being buried by debris.

2. An engineering investigation of the seismic stability of the dam and dike embankments.

3. A detailed hydrologic-hydraulic investigation to determine the adequacy of the spillway and discharge culvert and any necessary modifications to provide adequate capacity.

4. Engineering investigation for the reconstruction or modification of the low dike to the left of the dam to provide freeboard comparable to that of the dam and to provide erosion protection of its slopes and crest.

7.3 Remedial Measures

a. Operation and Maintenance Procedures - It is recommended that the following remedial work be undertaken by the Owner, in addition to the investigation outlined in Section 7.2, to correct deficiencies noted during the visual examination.

1. Repair stone riprap on the upstream slope at the locations where it has been displaced or damaged by erosion.

2. Place earth fill adjacent to the spillway walls and outlet structures to restore the spillway embankment in areas where it is low and eroded. Turf should be established over areas presently bare to resist erosion. If pedestrian traffic prevents the growth of turf, the embankment crest should be paved or otherwise protected.

3. Trim shrubbery on the downstream slope of the spillway embankment to facilitate visual examination of the slope.

4. Trim the brush on the slopes of the low dike to the left of the main dam.

5. Remove silted materials, cobbles and debris from the principal spillway inlet.

6. Patch eroded concrete areas at the principal spillway inlet and repair the upstream end of the overflow spillway sidewall.

7. Fill in the stone work at the outlet end of the principal spillway pipes and mortar or concrete the stone work in place.

8. Remove or transplant shrubbery at the outlet end of the left reservoir drain pipe.

9. Remove trees from the channel at the discharge end of culvert through the dam.

10. Prepare an operations and maintenance manual for the dam. The manual should include provisions for annual technical inspection of the dam and for surveillance of the dam during periods of heavy precipitation and high water levels. The procedures should delineate the routine operational procedures and maintenance work to be done on the dam, to ensure satisfactory operation and to minimize deterioration of the facility.

11. Develop a written emergency preparedness plan and warning system to be used in the event of impending failure of the dam. The plan should be developed in cooperation with local officials and downstream inhabitants.

7.4 Alternatives - There are no practical alternatives recommended.

APPENDIX A

INSPECTION TEAM ORGANIZATION AND CHECKLIST

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

DAM: Waldo Lake

DATE: 4 October 1978 with 23 March 1979 supplemental visit

TIME: 3:30 p.m.

WEATHER: Cloudy with lt. rain 50-55° F

WATER SURFACE ELEVATION UPSTREAM: 21" below overflow spillway crest

STREAM FLOW: negligible

INSPECTION PARTY:

1. Roger H. Wood - CDM (Structural/Operations)
2. Donna L. B. D'Amore - CDM (Hydraulics/Hydrology)
3. Charles E. Fuller - CDM (Hydraulics/Hydrology)
4. Harl P. Aldrich - Haley & Aldrich (Soils)
5. Richard Brown - Haley & Aldrich (3-23-79 supplemental visit)
6. _____

PRESENT DURING INSPECTION:

1. _____
2. _____
3. _____
4. _____

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Waldo Lake DATE: 4 October 1978
EMBANKMENT: Spillway Embankment

CHECK LIST	CONDITION
1. Upstream Slope	
a. Vegetation	1. a. Short areas, no trees or brush.
b. Sloughing or Erosion	b. Localized erosion from foot traffic and rainfall, especially around concrete headwalls.
c. Rock Slope Protection - Riprap Failures	c. Concrete fill and boulders, generally satisfactory.
d. Animal Burrows	d. None observed.
2. Crest	
a. Vegetation	2. a. Bare except for local areas of short grass.
b. Sloughing or Erosion	b. (See 1.b. above)
c. Surface cracks	c. None observed.
d. Movement or Settlement	d. None observed.
3. Downstream Slope	
a. Vegetation	3. a. Landscaped with evergreen shrubs and other plants; terraced with lines of boulders.
b. Sloughing or Erosion	b. Localized only; some boulders displaced.
c. Surface cracks	c. None observed.
d. Animal Burrows	d. None observed.
e. Movement or Cracking near toe	e. None observed.
f. Unusual Embankment or Downstream Seepage	f. None observed but toe submerged by ponded water.
g. Piping or Boils	g. None observed.
h. Foundation Drainage Features	h. None apparent.
i. Toe Drains	i. None apparent.
4. General	
a. Lateral Movement	4. a. None observed.
b. Vertical Alignment	b. Satisfactory.
c. Horizontal Alignment	c. (Curved)
d. Condition at Abutments and at Structures	d. Satisfactory.
e. Indications of Movement of Structural Items	e. None observed.
f. Trespassing	f. No restrictions; dam is in a park open to public.
g. Instrumentation Systems	g. None apparent.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Waldo Lake DATE: 23 March 1979

EMBANKMENT: Dam Embankment

CHECK LIST	CONDITION
1. Upstream Slope	
a. Vegetation	1. a. Generally well-maintained grass, clear of trees and brush.
b. Sloughing or Erosion	b. Localized erosion from foot traffic and rainfall.
c. Rock Slope Protection - Riprap Failures	c. Generally broken rock, cobbles and boulders to a level about 4 ft. above the spillway crest. Locally eroded at or below the high water line.
d. Animal Burrows	d. None observed.
2. Crest	
a. Vegetation	2. a. None; asphalt paved.
b. Sloughing or Erosion	b. None; pavement in good condition.
c. Surface cracks	c. No significant cracking.
d. Movement or Settlement	d. None apparent.
3. Downstream Slope	
a. Vegetation	3. a. Pine trees from 3 to 9-in. in diameter along top of slope and two young trees above culvert; otherwise some trees and brush near toe.
b. Sloughing or Erosion	b. None observed; slope well-protected by cobbles and boulders.
c. Surface cracks	c. None observed.
d. Animal Burrows	d. None observed.
e. Movement or Cracking near toe	e. None observed.
f. Unusual Embankment or Downstream Seepage	f. None observed, but some wetness noted below the toe.
g. Piping or Boils	g. None observed.
h. Foundation Drainage Features	h. None apparent.
i. Toe Drains	i. One 6-in. diameter pipe above the culvert structure - purpose not known.
4. General	
a. Lateral Movement	4. a. None observed.
b. Vertical Alignment	b. Good; pavement is pitched to drain towards lake.
c. Horizontal Alignment	c. Good.
d. Condition at Abutments and at Structures	d. Good.
e. Indications of Movement of Structural Items	e. None observed.
f. Trespassing	f. No restrictions; dam is in a park open to the public.
g. Instrumentation Systems	g. None apparent.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: WALDO LAKE DAM DATE: 4 OCTOBER 1978

SPILLWAY: SPILLWAY COMPLEX

CHECK LIST	CONDITION
1. Approach Channel a. General Condition b. Obstructions c. Log Boom etc.	(A) Principal Spillway (B) Left Reservoir Drain (C) Overflow Spillway (D) Right Reservoir Drain
2. Weir a. Flashboards b. Weir Elev. Control (Gate) c. Vegetation d. Seepage or Efflorescence e. Rust or Stains f. Cracks g. Condition of Joints h. Spalls, Voids or Erosion i. Visible Reinforcement j. General Struct. Condition	1.a. (A) has local erosion in concrete walls. (B) and (D) have deep erosion and deterioration in concrete walls approximately at normal reservoir level. (C) has stone masonry walls in good condition except for deterioration at the upstream end. All intake channels are in good condition but silting has occurred at (A), (B) and (D). b. None observed. c. None
3. Discharge Channel a. Apron b. Stilling Basin c. Channel Floor d. Vegetation e. Seepage f. Obstructions g. General Stuct. Condition	2.a. Stoplogs at (A), condition obscured by flow. None at (B), (C) and (D). b. None (A) and (C). Gate valves at (B) and (D). No operator handles. Rusted valve stems just above water. Gates covered with silt and cobbles. c. No material vegetation present. d. No material efflorescence present. e. None observed except for valve stems (D) and (B). f., g., h. See 1a. for (A), (B) and (D) headwalls. Center area at inlet between pipes at (A) is eroded. (C) has a few cracks in sidewall and cascade steps but is in good condition. i. None. j. The major portion of (A), (B) and (D) (pipes) are buried and not observable. (B) and (D) inlets are in poor condition structurally. (A) is in fair to good condition while (C) is in good condition. (A) has some rock debris just within stoplogs.
4. Walls a. Wall Location_____ (1) Vegetation (2) Seepage or Efflorescence (3) Rust or Stains (4) Cracks (5) Condition of Joints (6) Spalls, Voids or Erosion (7) Visible Reinforcement (8) General Struct.Condition	3.a. Apron present at (C) but under water. (A), (B), and (D) discharge at downstream ornamental steps which are

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: WALDO LAKE DAM DATE: 4 OCTOBER 1978

SPILLWAY: SPILLWAY COMPLEX (cont'd)

CHECK LIST	CONDITION
1. Approach Channel a. General Condition b. Obstructions c. Log Boom etc.	rock faced and soil backed with plantings. (A) is all rock at discharge. b. Common pool, water precluded inspection. c. See Special Structure for culvert through dam.
2. Weir a. Flashboards b. Weir Elev. Control (Gate) c. Vegetation d. Seepage or Efflorescence e. Rust or Stains f. Cracks g. Condition of Joints h. Spalls, Voids or Erosion i. Visible Reinforcement j. General Struct. Condition	d. None in pool - embankment steps planted. Planting interferes with (B) discharge. e. Not observeable. f. See d. g. Area in good condition but some undercutting at (A) discharge and planting obstructions at (B) discharge. Railing at all structures is in good condition.
3. Discharge Channel a. Apron b. Stilling Basin c. Channel Floor d. Vegetation e. Seepage f. Obstructions g. General Stuct. Condition	4. See 1.
4. Walls a. Wall Location_____ (1) Vegetation (2) Seepage or Efflorescence (3) Rust or Stains (4) Cracks (5) Condition of Joints (6) Spalls, Voids or Erosion (7) Visible Reinforcement (8) General Struct.Condition	

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: WALDO LAKE DAM DATE: 4 OCTOBER 1978

SPECIAL STRUCTURE: CULVERT THRU DAM

CHECK LIST	CONDITION
Culvert	Mortar fieldstone headwalls upstream and downstream with concrete twin barrel box culvert. The entrance to the box culvert has been constricted by stone work probably to maintain the stilling basin pool. Observed structure in good condition. Only minor efflorescence noted on the upstream walls. Railing in good condition. Upstream side has adjacent soil erosion due to foot traffic. Downstream channel has an irregular rock-covered invert with 8 trees in the middle of the channel near culvert discharge. Below this, the channel becomes a woodland stream.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: WALDO LAKE DAM DATE: 4 OCTOBER 1978

HYDROLOGIC-HYDRAULIC CONSIDERATIONS:

CHECK LIST	CONDITION
1. Upstream Watershed a. Type of Terrain b. Hydrologic Controls	1. a. Rolling to flat, heavily wooded; several wetland areas; minimal development. b. Brockton Reservoir Dam
2. Reservoir a. Type of Terrain b. Development	2. a. East side slopes are flat; West side slopes are steep. b. No development.
3. Spillway a. Adjacent Low Points b. Spillway Approach (Slope) c. Spillway Discharge (Slope) d. Spillway Type	3. Main Spillway a. None b. Not possible to determine. c. Vertical d. Sharp-crested weir. Ornamental Spillway a. None b. Not possible to determine. c. Vertical (.606) d. Broad-crested weir.
4. Downstream Watershed a. Reach No. (1) Control (Bridge, dam, culvert, etc.) (2) Channel Characteristics (3) Development (4) Visible Utilities (5) Special Problems (Hospital, etc.)	4. a. Reach No. 1 (1) Upper Porter Pond Dam. (2) Natural channel approximately 17 feet wide. (3) Minimal residential development. (4) Overhead Telephone, Electric. (5) None. b. Reach No. 2 (1) Lower Porter Pond Dam. (2) Oak Street Culvert, Arch 15' wide X 7' high. (3) Minimal development. (4) None (5) None c. Reach No. 3 (1) Thirty Acre Pond Dam (2) D.W. Field Parkway Culvert, Twin Arches 12.5' wide X 7' high. (3) None (4) None (5) None

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: WALDO LAKE DAM DATE: 4 OCTOBER 1978

HYDROLOGIC-HYDRAULIC CONSIDERATIONS: (cont'd)

CHECK LIST	CONDITION
	d. Reach No. 4 (1) Ellis Brett Pond Dam. (2) Natural Channel approximately 10 feet wide. (3) Moderate residential development. (4) None (5) None e. Reach No. 5 (1) Cross Pond Dam. (2) Natural Channel approximately 12 feet wide. (3) Dense residential and commercial development. (4) Overhead Telephone and Electric. (5) None.

APPENDIX B

LIST OF AVAILABLE DOCUMENTS AND PRIOR INSPECTION REPORTS

DAM NO 139

COUNTY OF PLYMOUTH, MASSACHUSETTS
ENGINEERING DEPARTMENT
INSPECTION OF DAM AND RESERVOIRS

Inspector Bamber & Gfroerer Date Nov. 1936 City or Town Brockton.

Location Southerly end of Waldo Lake on D.W. Field Parkway.

Owner City of Brockton. Use Parkway - Ornamental.

Material and Type Earth & Clay Dyke; Concrete & Stone Spillway; Paved Slope at Spillway.

Maximum Head in Feet (Full Pond Level to Bottom of Spillway) 11 feet 2 inches.

Length 400 feet. Width 30 feet. (minimu

Area of Watershed 6 Square Miles. Capacity 180,000,000 Gallons

Length of Overflow or Spillway 15 feet 6 inches. Outlets (Pipes or Flumes)

6 - 36" Pipes.

Dam Constructed by D.W. Field & W.P.A. Date 1935-6

Recent Repairs Date

Evidence of Leakage Noticeable leakage on inner or Spillway dam.

Condition Outer dam (Roadway) is sound.

Topography of Country Below Series of Ponds and Salisbury Brook through Brock

Nature, extent, proximity, etc. of buildings, roads or other property in danger if failure should occur

Complete failure would take out Upper Porter Dam, Lower Porter Dam, 30 Acre Pond Dam, Ellis Brett Dam; wash out two or three stre and flood numerous cellars throughout the city.

Remarks and Recommendations Spillway area ample. Area of culvert under road reduced for safety 1939-40 as suggested. Failure of the Reservoir Dam in Avon (unlikely) would tax and damage the spillway but probably nothing more. Dam filled - some leakage Aug. 1940. Unchanged Unchanged May, 1944. No change Sept. 1946. Good - no change Nov. 1948. Sound - no changes Nov. 1950. Good - inner dam seems sound May 1951. Some leakage thru stone fills & west pip Fair at present. July 1952. Much water - apparently sound Feb. 1953. Sound Dec. 1954. All good shape - slight leakage at spillway. Sept 1956 Good Oct. 1957. Good condition Sept. 1958. Fair flow - small leakage east of spillway Oct. 1960. Good Oct. 1962. Good - no change Oct 1964 Good - no change Dec. 1966. Good - no change Oct 1968. Good - no ch Oct 1969

INSPECTION REPORT - DAMS AND RESERVOIRS (139)

1. Location: City/~~Town~~ BROCKTON Dam No. 7-12-44-9

Name of Dam WALDO LAKE Inspected by: A. DUGAN

Date of Inspection 12-5-72

2. Owner/s: Per: Assessors X Prev. Inspection 12-8-72

Reg. of Deeds _____ Pers. Contact _____

1. CITY OF BROCKTON, CITY HALL, BROCKTON, MASS. 624.
Name St.& No. City/Town State Tel.No.

Name St.& No. City/Town State Tel.No.

Name St.& No. City/Town State Tel.No.

3. Caretaker: (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

PARK COMM.
Name St.& No. City/Town State Tel.No.

4. No. of Pictures taken NONE

5. Degree of Hazard: (if dam should fail completely)*

1. Minor _____ 2. Moderate _____

3. Severe X 4. Disastrous _____

*This rating may change as land use changes (future development)

6. Outlet Control: Automatic _____ Manual _____

Operative _____ yes; _____ No

Comments: FLOWS OVER OPEN WEIR

7. Upstream Face of Dam: Condition:

Conditions:

1. Good X 2. Minor Repairs _____

3. Major Repairs _____ 4. Urgent Repairs _____

Comments: RIP RAP INSTALLED THIS YEAR

APPENDIX B-2

Dam No. 7-12-11-9

8. Downstream Face of Dam:
Condition: 1. Good _____ 2. Minor Repairs X
3. Major Repairs _____ 4. Urgent Repairs _____
Comments: Trees

9. Emergency Spillway:
Condition: 1. Good X 2. Minor Repairs _____
3. Major Repairs _____ 4. Urgent Repairs _____
Comments: _____

10. Water Level at Time of Inspection:
2 1 ft. above _____. below X. top of dam _____
principal spillway X. other _____.

11. Summary of Deficiencies Noted:
Growth (Trees & Brush) on Embankment N
Animal Burrows & Washouts N
Damage to Slopes or Top of Dam N
Cracked or Damaged Masonry N
Evidence of Seepage N
Evidence of Piping N
Erosion N
Leaks N
Trash and/or Debris Impeding Flow N
Clogged or Blocked Spillway N
Other _____

12. Remarks & Recommendations: (Fully Explain)

PARK ROAD IS THE MAIN

13. Overall Condition:

1. Safe X
2. Minor Repairs Needed
3. Conditionally Safe - Major Repairs Needed
4. Unsafe
5. Reservoir Impoundment no Longer Exists (explain)

   Recommend Removal from Inspection List

INSPECTION REPORT - DAMS AND RESERVOIRS

1. Location: City/~~Town~~ Brockton Dam No. 7-12-44-9

Name of Dam Waldo Lake Inspected by: K.B. Harrison & G.G. Bumpus

Date of Inspection: 6-26-75

2. Owner/s: Per: Assessors ✓ Prev. Inspection 12-8-72

Reg. of Deeds _____ Pers. Contact _____

1. City of Brockton, City Hall, Brockton, Mass.
Name St. & No. City/ Town State Tel. No.

Name St. & No. City/Town State Tel. No.

Name St. & No. City/Town State Tel. No.

3. Caretaker:(if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Name St. & No. City/Town State Tel. No.

4. No. of Pictures taken: None

5. Degree of Hazard: (if dam should fail completely)*

1. Minor _____ 2. Moderate _____

3. Severe ✓ 4. Disastrous _____

*This rating may change as land use changes (future development)

6. Outlet Control: Automatic ✓ Manual _____

Operative ✓ Yes _____ No

Comments: Water flows over an open weir (fixed elevation)

7. Upstream Face of Dam: Condition:

Conditions:

1. Good ✓ 2. Minor Repairs _____

3. Major Repairs _____ 4. Urgent Repairs _____

Comments: Construction earth & riprap.

Excellent condition

Dam No. 7-12-44-4

8. Downstream Face of Dam:

Condition: 1. Good ✓ 2. Minor Repairs _____

3. Major Repairs _____ 4. Urgent Repairs _____

Comments: Trees - but at no danger due to extreme width & height of dyke.

9. Emergency Spillway: Yes (3) - One with flashboards.

Condition: 1. Good _____ 2. Minor Repairs ✓

3. Major Repairs _____ 4. Urgent Repairs _____

Comments: The two emergency spillways adjacent to the principal overflow spillway have deteriorated conc. in the wingwalls - no danger, but should be patched.

10. Water Level at Time of Inspection:

7.7 ft. _____ above. ✓ below. _____ top of dam.

_____ principal spillway. secondary spillway with flashboards other.

11. Summary of Deficiencies Noted:

Growth (Trees & Brush) on Embankment No

Animal Burrows & Washouts No

Damage to Slopes or Top of Dam No

Cracked or Damaged Masonry Yes - wingwalls - secondary spillways.

Evidence of Seepage No

Evidence of Piping

Erosion

Leaks

Trash and/or Debris Impeding Flow

Clogged or Blocked Spillway No

Other

12. Remarks & Recommendations (fully explain)

Park Rd itself makes up the dam and has good height & width. Upstream & downstream faces in good condition.

Some patchwork is needed on the wingwalls of the two emergency spillways adjacent to the overflow spillway. The concrete is badly deteriorated on these wingwalls - but of no danger at the present time.

13. Overall Condition:

1. Safe ✓
2. Minor Repairs Needed ✓
3. Conditionally Safe - Major Repairs Needed
4. Unsafe
5. Reservoir Impoundment no Longer Exists (explain)

Recommend Removal from Inspection List

DESCRIPTION OF DAM

DISTRICT 7

Submitted by K B Harrison Dam No. 7-12-44-9

Date 7-31-75 City/~~Town~~ Brockton

Name of Dam Walla Lake

1. Location: Topo Sheet No. 32 D

Provide 8½" x 11" in clear copy of topo map with location of Dam clearly indicated.

2. Year Built 1935-36 Year/s of Subsequent Repairs well maintained

3. Purpose of Dam: Water Supply _____ Recreational ✓

Irrigation _____ Other _____

4. Drainage Area: 6 Sq.Mi. _____ Acres

5. Normal Ponding Area: _____ Acres _____ Ave.Depth

Impoundment: 180,000,000 Gals. _____ Acre Ft.

6. No. and Type of Dwellings Located Adjacent to Pond or Reservoir

i.e. Summer Homes, etc. None

7. Dimensions of Dam: Length 400' Max. Height 11'+

Slopes: Upstream Face Varies - min of 2:5'

Downstream Face " " of 3:0'

Width Across Top 30'+

8. Classification of Dam by Material:

Earth ✓ Conc. Masonry _____ Stone Mason. ✓

Timber _____ Rockfill ✓ Other Park Rd.

DAM NO. 7-12-44-9

9. A. Description of Present Land Usage Downstream of Dam:

0 % rural 100 % urban

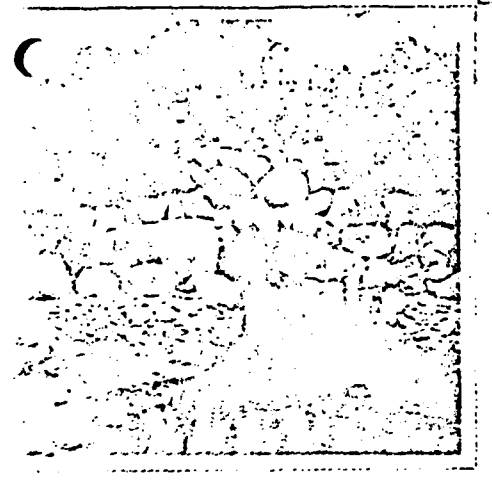
B. Is there a storage area or flood plain downstream of dam which could accommodate the impoundment in the event of a complete dam failure _____ yes probably not.

10. Risk to Life and Property in Event of Complete Failure

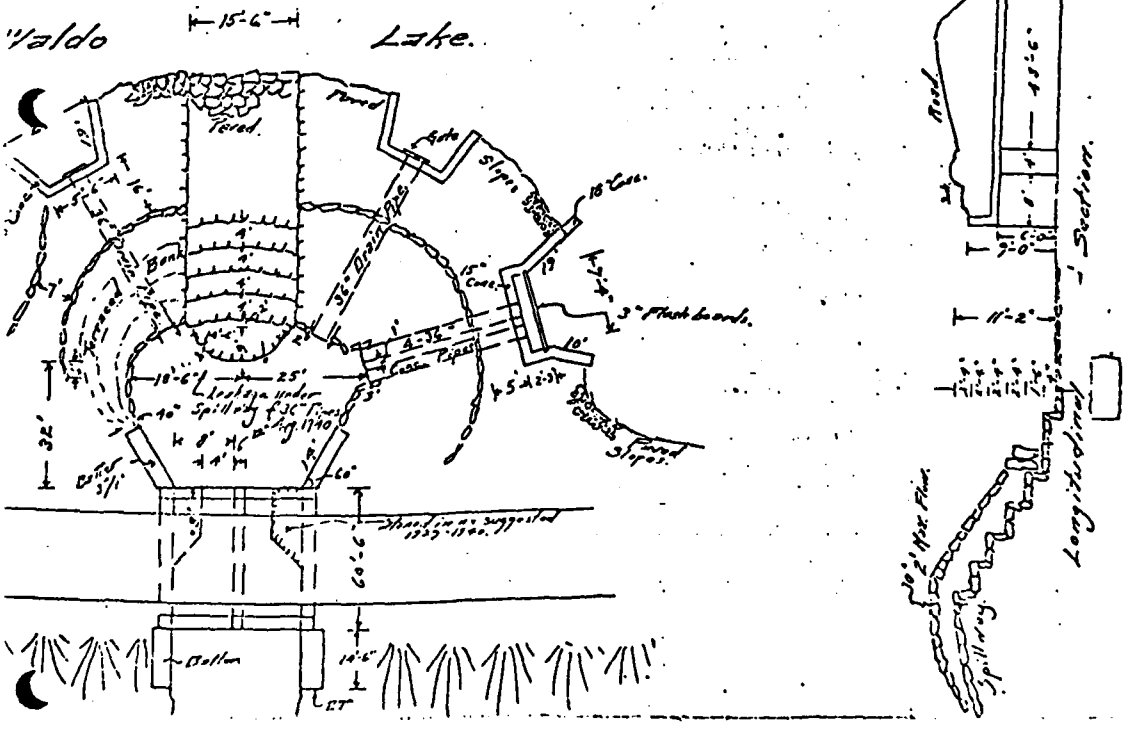
No. of People _____
No. of Homes _____ } Numerous
No. of Businesses _____
No. of Industries _____ Type _____
No. of Utilities 4 Type Gas, Water, Tel & Elect.
Railroads 0
Other Dams 7-12-44-4,5,6,7 & 8
Other Center of City.

11. Attach sketch of dam to this form showing section and plan on an 8½" x 11" sheet.

Dam #7-12-44-9

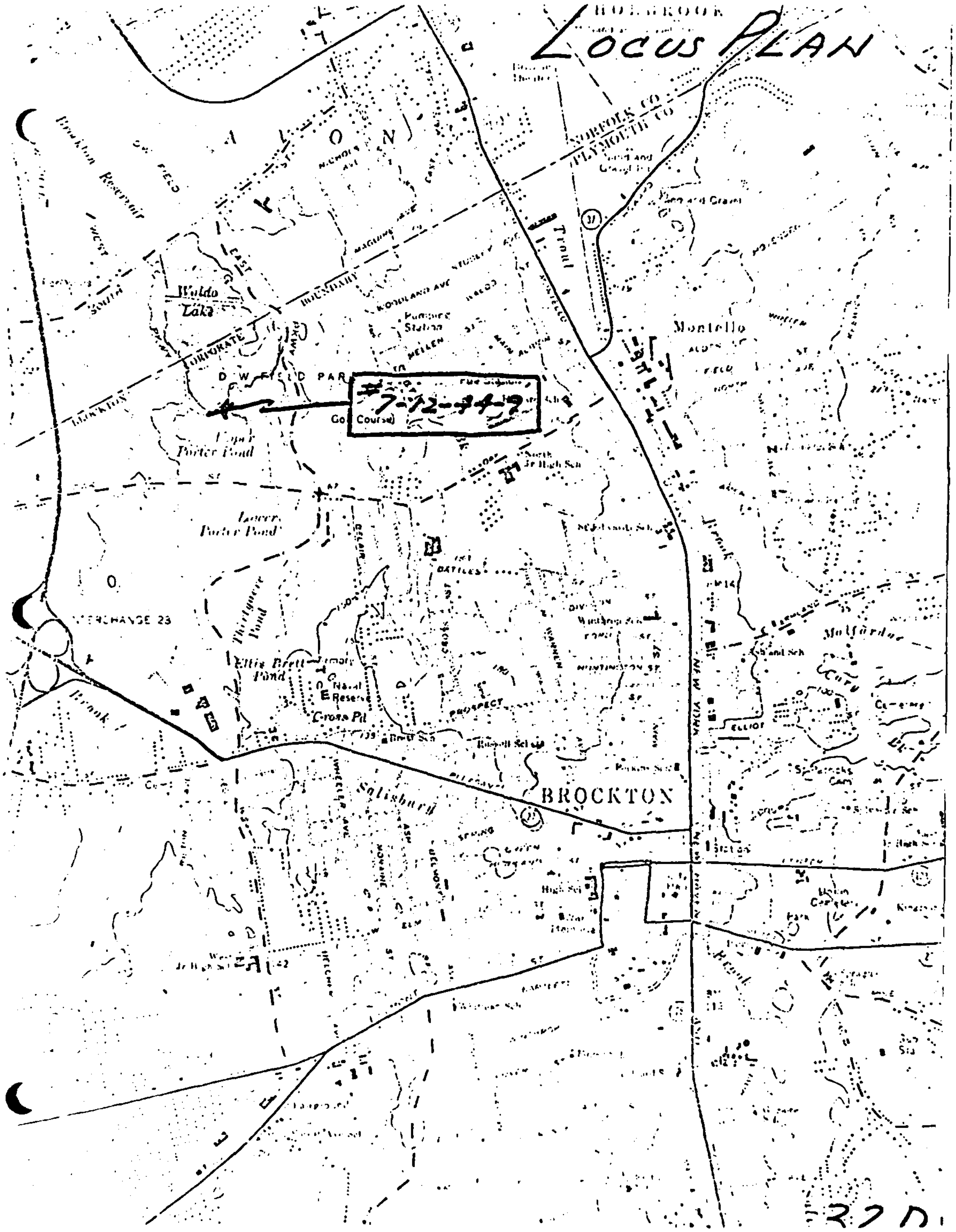


Sketch of Dam (not to Scale)



Dam #7-12-44-9

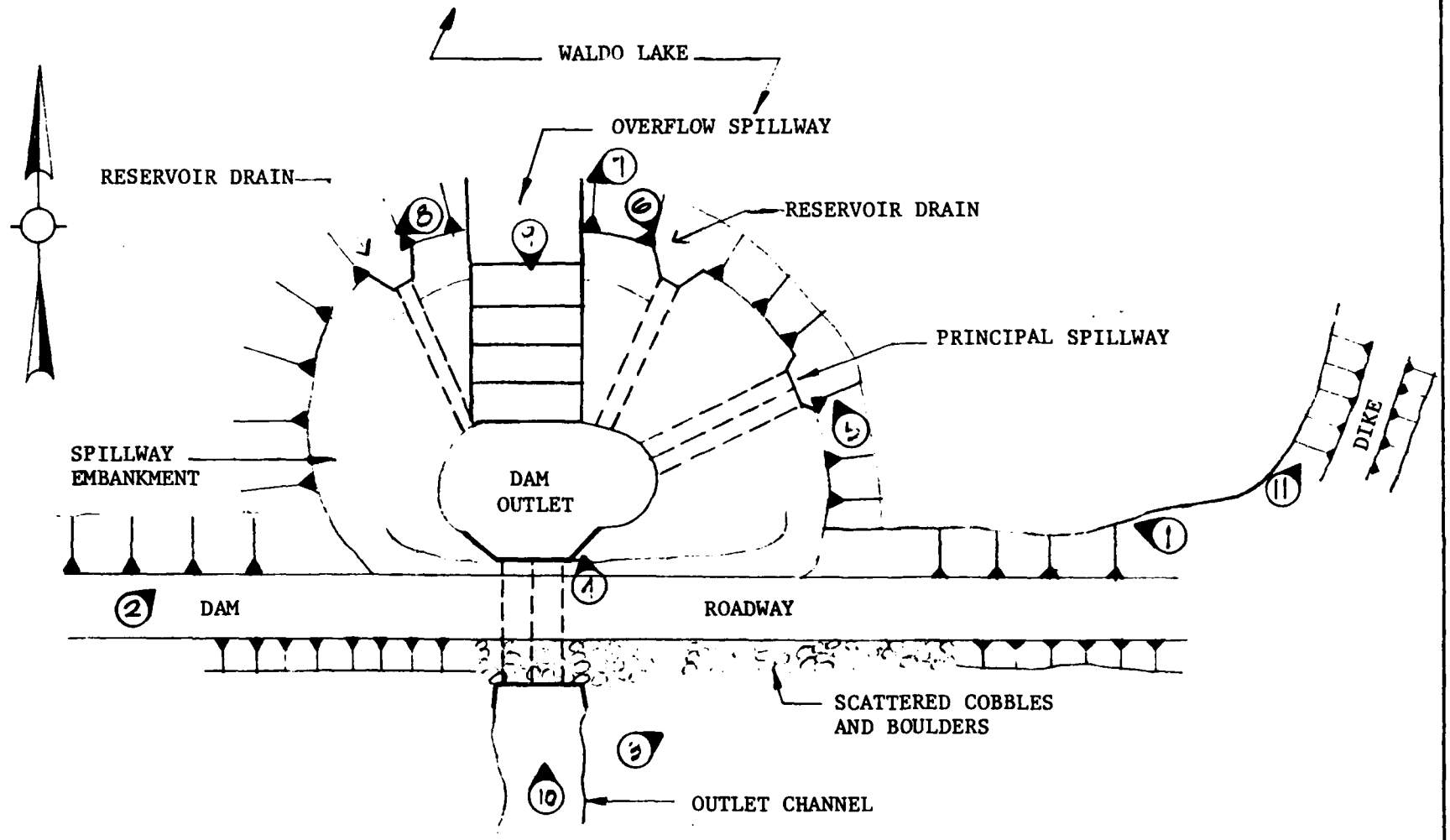
APPENDIX B-10



APPENDIX B-11

APPENDIX C

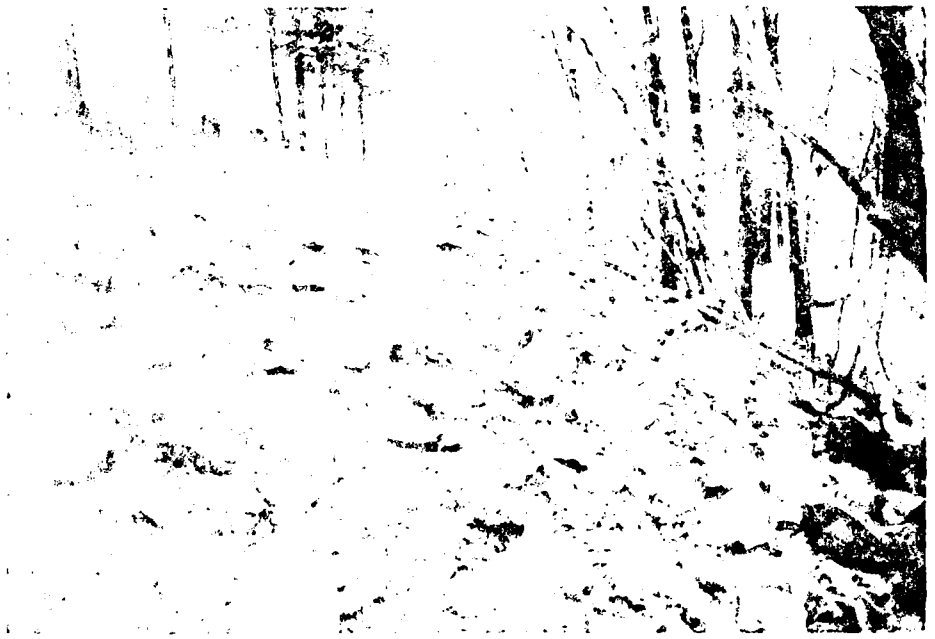
SELECTED PHOTOGRAPHS OF PROJECT



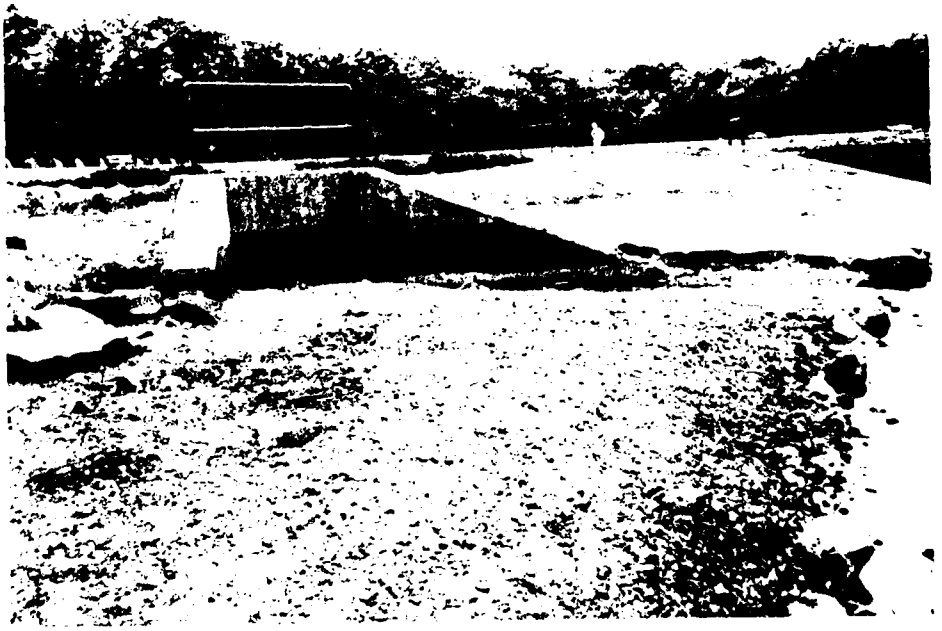
APPENDIX C-1

(1) Denotes direction of view and photograph number.

National Program of Inspection of Non-Federal Dams
Location of Photographs
Waldo Lake Dam
Brockton, Massachusetts



4. Overview of spillway from dam.

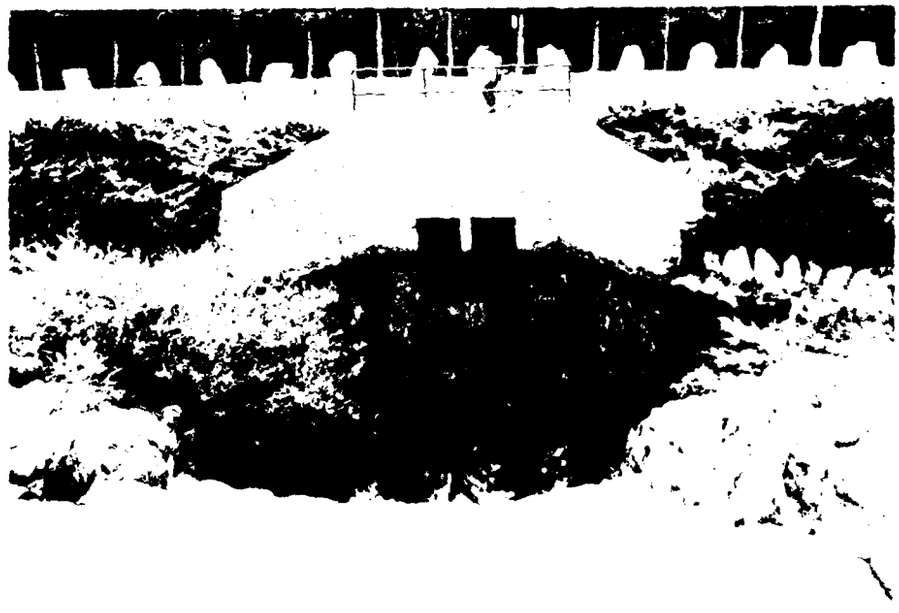


5. Upstream headwall of left spillway (principle spillway).

6. Upstream left wingwall of left reservoir drain.

7. Upstream right sidewall of emergency spillway.

8. Upstream right wingwall of right reservoir drain.



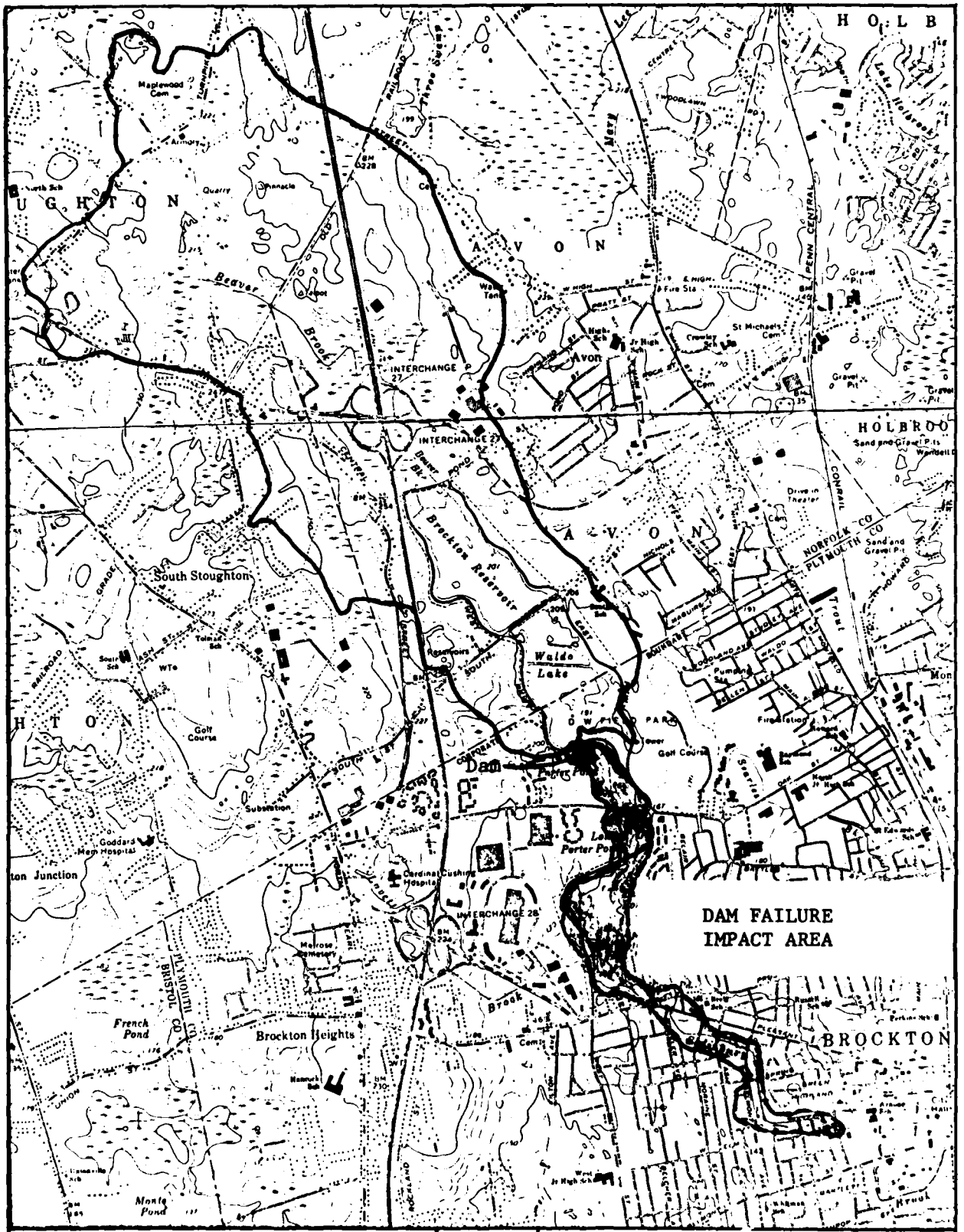
9. Spillway stilling pool and upstream face of culvert through dam.

10. Downstream face of culvert through dam.

11. Upstream face and crest of dike east of dam.

APPENDIX D

OUTLINE OF DRAINAGE AREA AND HYDRAULIC COMPUTATIONS



CAMP DRESSER & McKEE INC.
Consulting Engineers
Boston, Massachusetts 02108

WALDO LAKE DAM
DRAINAGE AREA MAP AND
DAM FAILURE IMPACT AREA

APPROX. SCALE: 1" = 3077'

APPENDIX D-1

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT NDI / COE
PROJECT Wallace Lake
DETAIL Hydraulics / Hydrology

JOB NO. 390-5-16
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PAGE 1 of 32
DATE 1/9/79
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Size Classification

Top of Dam: Elev. = 197.5 (approximate top of road)
Spillway Crest Elev. = 191.6
Downstream Channel = 180.5
Invert

Height of Dam = 17 feet
Storage (to top of dam) = $\frac{1}{3} \times 77 \times 11.1$ ft.
$+ \left(\frac{77+126}{2}\right) 5.9$ ft.

Maximum Anti Storage = 884 Ac-ft.

Size Category is SMALL

Hazard Classification

HIGH

Test Flood

½ PMF to PMF

Hazard Analysis

Length of Dam = 400 ft.

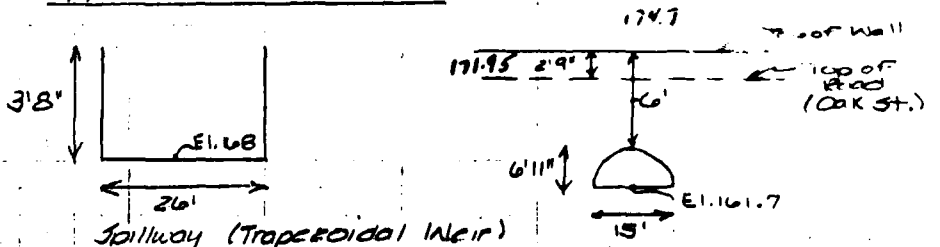
For dam failure, assume failed section to be approximately 40 ft. (section adjacent to and including the outlet culvert)

1. At time of failure, S = 884 Acre-ft. (38,507,040 ft³)

2. $Q_{p_1} = \frac{8}{27} \times 40\,ft \times \sqrt{32.2} \times 17^{3/2} = 4711\ cfs$

3. Control Section at Outlet of Upper Porter Pond

Upper Porter Pond Weirs



Spillway (Trapezoidal Weir)

Oak St. is 75 feet wide.

Elevations

Crest Elev: 168.0'
Top Dam: 171.95 (top of road)
Invert Culvert: 161.7'
Top of Spillway Sidewalls: 171.7'

Cut stone and mortared spillway; vertical side walls

Spillway Rating Curve

Elev.	Head	Length	C Value T.S-11	Q
168.0	0	26		0
169.0	1	26	3.07	80
170.0	2	26	3.29	242
171.0	3	26	3.38	457
171.7	3.7	26	3.35	620
171.95	3.95; 2.5	26; 375	3.35; 2.5	684; 117
173.0	5.0; 1.3	26; 1000	3.35; 2.5	974; 3706
175.0	7.0; 3.3	26; 1300	3.35; 2.5	1613; 19483

Note: C values taken from Table 5-11 with a 10% reduction in value because of spillway construction.

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass

CLIENT COE / NDT
PROJECT Walden Lake
DETAIL Hydraulics / Hydrology

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PAGE 30 OF 32
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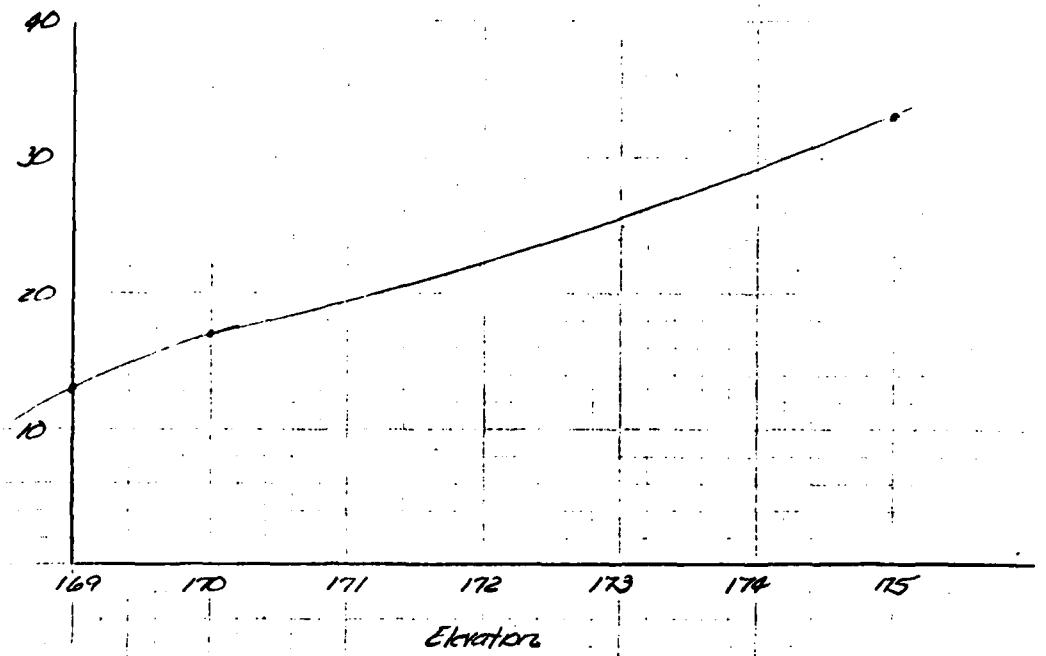
Upper Porter Pond

Elev	Surface Area
169	13 A
170	16.8 A
175	33 A



APPENDIX D-4

Culvert Rating Curve

	Head	Elev.	C value	Area	Q	
	0	161.7			0	
Culvert full pressure	7	168.7		82.5	220	Mannings
	13	170.0	0.91	82.5	687	
	3.25	171.95	0.91	82.5	1086	
	4.30	173.0	0.91	82.5	1250	

Area culvert = $(\pi \times 7 \times 7.5)/2$ = 82.5 ft²

WP = 37.8 ft
S = .0005
R = 2.182 ft.
n = .021

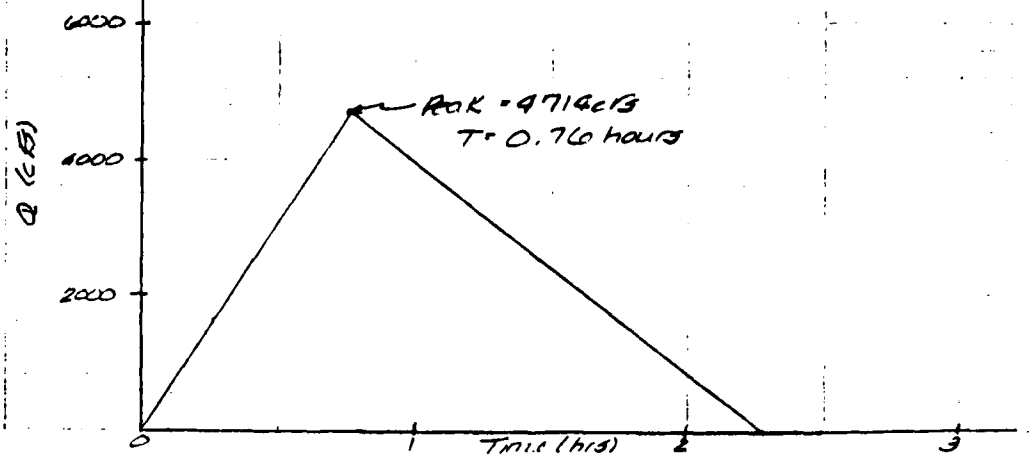
Culvert appears to be able to contain the flows generated by pond level in Upper Porter reaching Elevation 171.95.

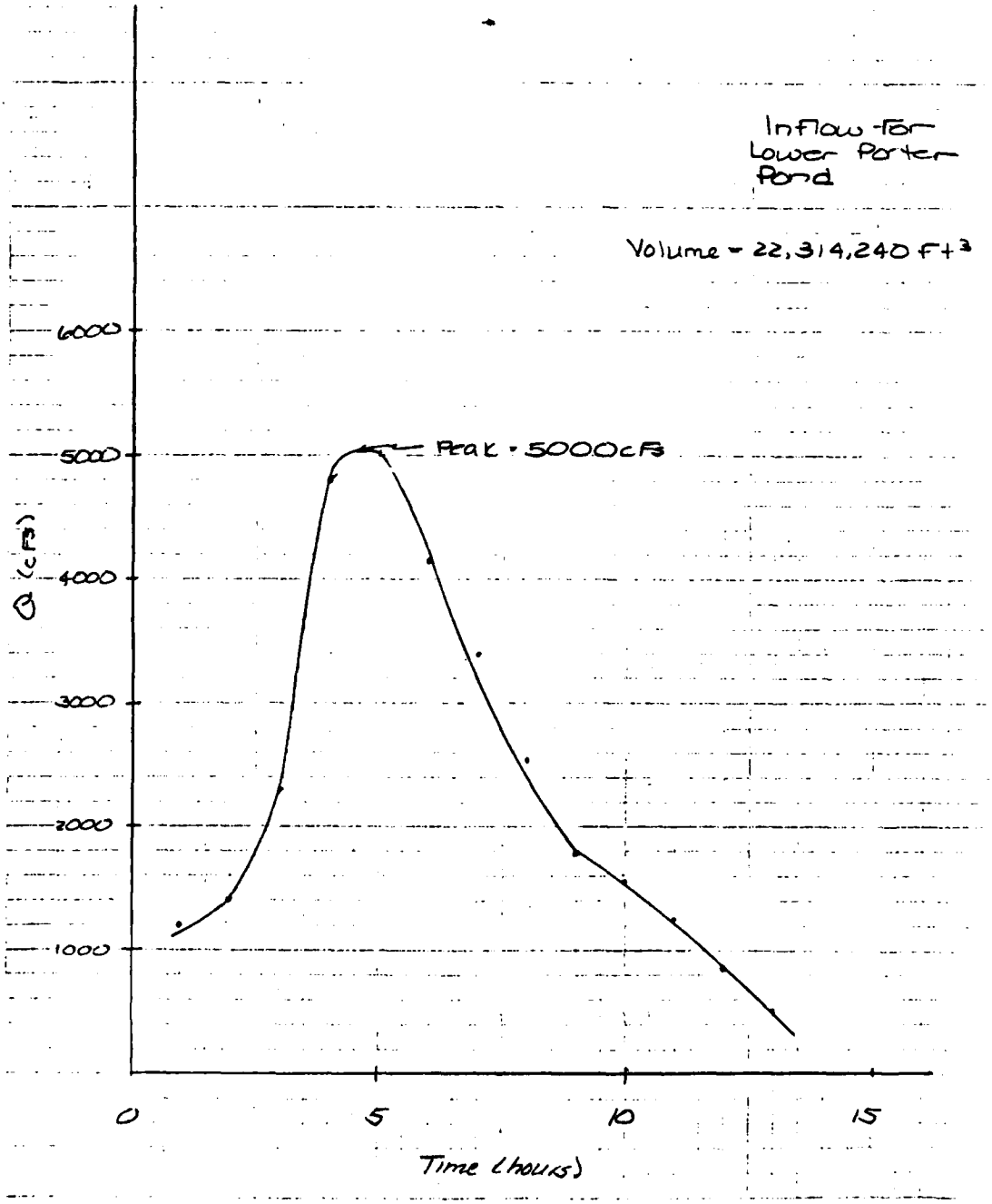
Use spillways' capacities in routing the flow from a dam failure at Waldo Pond.

Construct Triangular InFlow Hydrograph

S = 38,507,040 ft³
Q = 4714 cfs

Length of Hydrograph: $\frac{38507040}{4714}$ = 8169 secs
= 2.27 hours




Inflow for Lower Porter Pond
Volume = 22,314,240 Ft³
Peak = 5000cfs
Q (cfs)
6000
5000
4000
3000
2000
1000
0
5
10
15
Time (hours)

APPENDIX D-6

Total Q Capacities

Elevation	Q spillway	Q culvert	Q Total
168	0	0	0
169	80	380	460
170	242	687	929
171	457	885	1342
171.7	620	1025	1645
171.95	801	1006	1887
173.0	4680	1250	5930
175.0	21096	1512	22608

Head	Elev. of W.S.	Res. Area (acres)	Calc. Outflow Q	Calc Storage	$\frac{S}{\Delta t}$	$\frac{S}{\Delta t} - \frac{Q}{2}$	$\frac{S}{\Delta t} + \frac{Q}{2}$
0	168	12	0	0	0	0	0
1	169	13	460	12.5	756	526	986
2	170	16.8	929	27.4	1658	1193	2122
3	171	19.3	1342	45.5	2753	2082	3424
3.7	171.7	21.4	1645	59.7	3612	2789	4434
3.95	171.95	22.1	1887	65.1	3939	2995	4882
5	173	25.3	5930	90.0	5445	2980	8410
7	175	33	22608	148.3	8972	-2332	20276

Δt = 12 min. = 720 sec.

Time Hr	Obs. Inflow	Avg. Inflow	$\frac{S}{\Delta t} - \frac{Q}{2}$	$\frac{S}{\Delta t} + \frac{Q}{2}$	Head on Spillway	Elev	Outflow Q
0	0	0					0
1	1200	600			2.6	170.6	1200
2	2450	1825	1729	3554	3.1	171.1	1400
3	3650	3050	2173	5223	4.06	172.06	2310
4	4550	4100	2945	7045	4.71	172.71	4813
1hr. 5	3950	4250	2679	6929	4.76	172.76	5006
6	3300	3625	2696	6321	4.54	172.54	4159
7	2700	3000	2785	5785	4.33	172.33	3406
8	2100	2400	2863	5263	4.12	172.12	2542
9	1500	1800	2939	4739	3.90	171.90	1790
2hr 10	850	1175	2929	4104	3.48	171.48	1550
11	250	550	2567	3117	2.74	170.74	1235
12	0	125	1872	1997	1.86	169.86	863
13	0	0	1120	1120	1.12	169.12	516
14	0	0					

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PAGE 7 of 32
DATE 1/11/79
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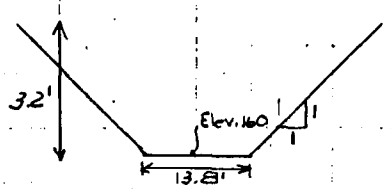
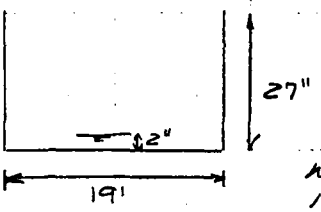
Lower Porter Pond



Spillway A

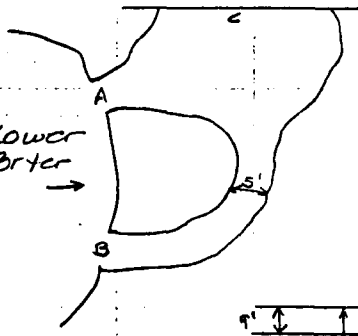


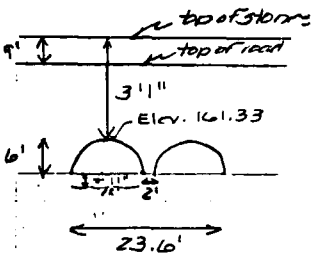
Spillway B

Water depths are 12/28/78

Thirty Acre Pond

Park Road (41.4' wide)





Culvert C

Elevations:
Top of Road = 163.66
Spillway A Crest = 160.0
Spillway B Crest = 159.83
Culvert C Invert = 159.41

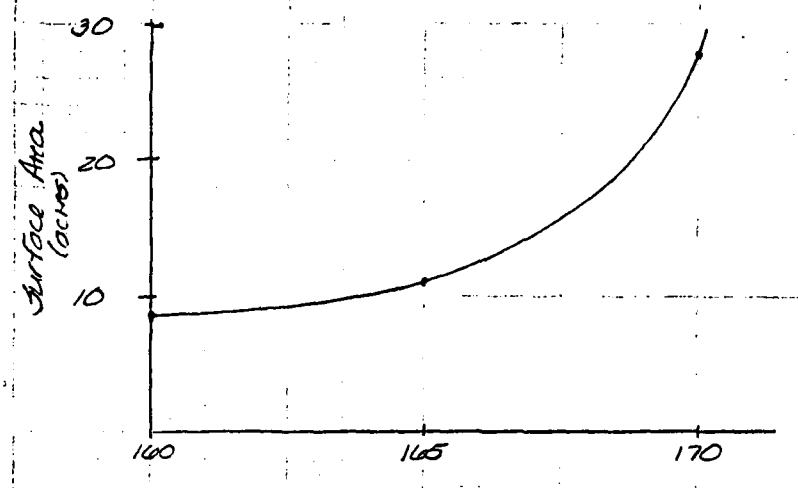
Spillway capacity calculations

Elev. W.S.	C_A	H_A	Q_A	C_B	H_B	Q_B	Q_{TOTAL} 2 Spillways
160		0	0	3.05	0.17	4.1	4.1
161	3.07	1	45.0	3.11	1.17	74.8	119.8
162	3.29	2	143.8	3.30	2.17	200.4	344.2
163	3.38	3	286.0	3.37	3.17	361.4	647.4
163.66	3.35	3.66	395.0	3.35	3.83	477.1	872.1
164.00	3.35	4.0	459	3.35	4.17	542.2	1001.2

$Q = C_{tor} \frac{\theta}{2} H^{5/2}$

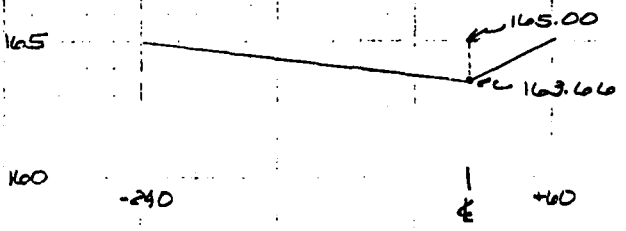
Lower Porter

Elev.	Surface Area
160	8.3 A
165	11.2 A
170	27.7 A



Road Profile

at Lower Porter Pond



Culvert capacity calculations (Culvert C)

Elev. of W.S.	"C" Value	A (sq. ft.)	Q (cfs)
163.66	0.71	117.4	1021
164.00	0.71	117.4	1093
165.00	0.71	117.4	1281
166.00	0.71	117.4	1446
167.00	0.71	117.4	1593

WP (2 culverts) $= 2\pi\sqrt{\frac{(10.3)^2+7^2}{2}} = 55.3$ ft

e = 4.10

Slope = 0.0005

Roadway as a spillway calculations

$Q = C \tan\frac{\theta}{2} H^{5/2}$

Elev. of W.S.	"C" Value	Head on Roadway	Q
163.66	2.50	0 Ft.	0 cfs
164.00	2.50	0.34	12
165.00	2.50	1.34	372
166.00	2.50	2.34	1500
167.00	2.50	3.34	3650

Combined Capacities

Elev. M.S.L.	$Q_{spillway}$	$Q_{culvert}$	$Q_{road\ +\ overland}$	Q_{TOTAL}
160	4	179	—	179
161	120	212	—	212
162	347	548	—	548
163	656	864	—	864
163.66	887	1021	—	1021
164	1019	1093	12	1105
165	—	1281	372	1653
166	—	1946	1500	2996
167	—	1593	3650	5243

Generalized Estimate of Reservoir Outflows
Fair and Geyer, pg. 207

Ratio of storage above spillway level to flood flow

Flood Flow: Peak = 5006 cfs
Length of storm = 2.92 hours

Volume of storm Flow = 22,314,240 ft³

Storage above spillway level to top of road = $\left(\frac{2.3+10}{2}\right)$ 3.66 x 43560 = 1,458,781

Ratio = $\frac{1,458,781}{22,314,240} \approx 6.54\%$

∴ Ratio of peak outflow ≈ 98% to peak inflow

∴ Inflow Hydrograph into Thirty Acre Pond is similar to Inflow Hydrograph into Lower Porter Pond. However, peak inflow =

5006 x 0.98 ≈ 4906 cfs

say 4900 cfs

$\left(\frac{4906}{5006}\right)$ x 22,314,240 = 21,868,490

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PAGE 11 OF 32
DATE 1/19/79
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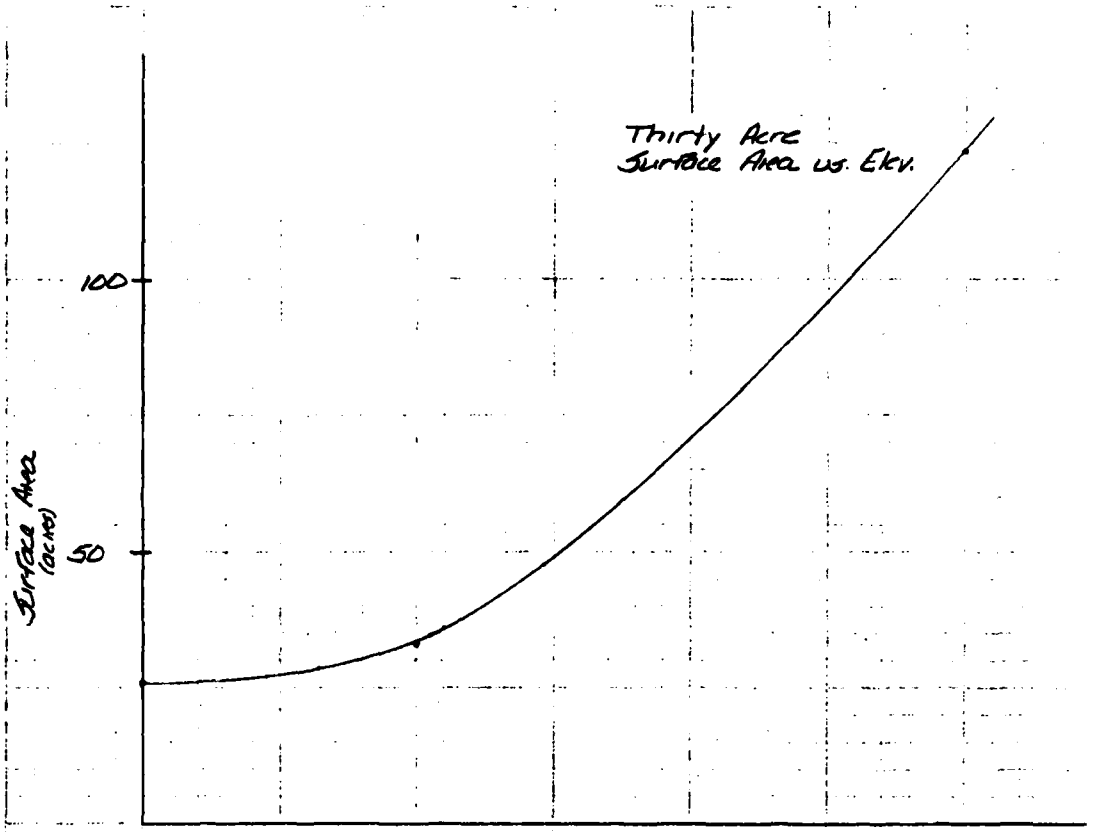


Generalized Estimate of Reservoir Outflows
Fair and Geyer, pg. 207

Ratio of Storage above Spillway Level to Flood Flow

Flood Flow = 21,868,490 ft³ for storm duration

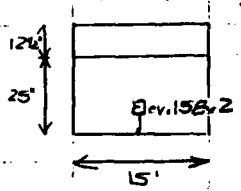
Storage Above Main Spillway Level to Top of Road $\left(\frac{25.7+32}{2}\right)(5.50') \cong 159$ Acre-Ft.
$= 6,926,040$ ft³

APPENDIX D-12

Thirty Acre Pond

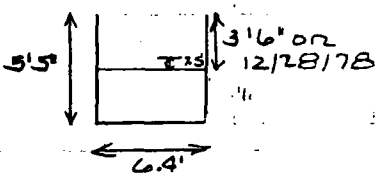
Outlet Works.

a. Ornamental Spillway



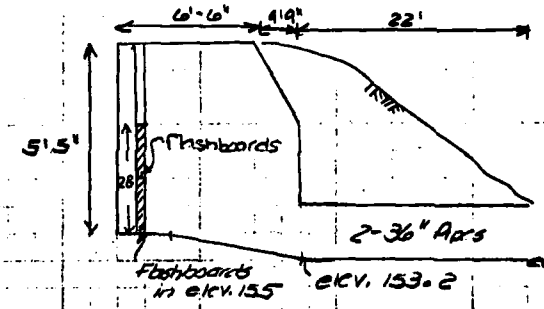
Elevation of Crest: 158.2
Top of Dam: 160.5

b. Main Spillway



Elevation of Crest = 155

Main Spillway Profile



Main Spillway Rating Curve

King & Brater: Figure 5-22

Note: Dam Length = 592 ft.

Elev. W.S.	Head on Spillway	"C" Value	Q (cfs)
155	0		0
156	1	3.54	23
157	2	3.50	63
158	3	3.27	109
159	4	3.25	166
160	5	3.25	233
160.5	5.5	3.25	268
161	6	3.25	306 + [2.5 x 0.5^3/2 x (592-21.4)] = 810
162	7	3.25	385 + [2.5 x 1.5^3/2 x (592-21.4)] = 3006
163	8	3.25	471 + [2.5 x 2.5^3/2 x (592-21.4)] = 6110

Twin 36" ϕ Concrete Pipe Capacities

Elev. W.S.	Head on Culvert	"C" Value	Q (cfs)	
156.1	0	—	90	flowing full
157.1	1	.90	102	
158.1	2		144	
159.1	3		177	
160.1	4		204	
161.1	5		228	
162.1	6		250	

Ornamental Spillway Rating Curve

King and Brater ; Fig 5-12

Elev. W.S.	Head on Spillway	"C" Value	Q (cfs)
158.2	0		0
159	0.8	3.50	38
160	1.8	3.37	122
160.5	2.3	3.32	174
161	2.8	3.32	233
162	3.8	3.37	374
163	4.8	3.38	533

Total Spillway Capacities

Elev. of W.S.	Q_{TOTAL}
155	0
156	23
157	63
158	109
159	204
160	355
160.5	446
161	1043
162	3380
163	6643

Ratio = $\frac{6926040\ ft^3}{21,868,490\ ft^3}$ = 31.7 %

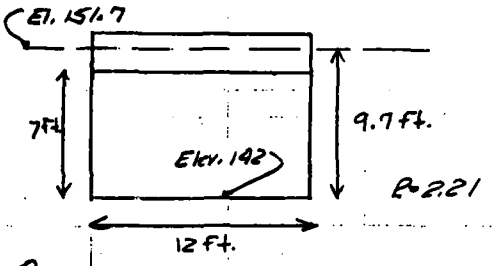
∴ Ratio of peak outflow ≅ 84.5%
to peak inflow

∴ peak outflow of Thirty Acre Pond = 4900 cfs X .845
= 4140 cfs

Minor Flooding of Park Road on North-West Side of Thirty Acre Pond.

Ellis Beth Pond

Outlet Works
Spillway Crest = 142'
Top of Dam = 151.7'
Crown of Spill. = 149'
way Structure



	Elev. W.S.	Head on Spillway	"C" value	Q (cfs)
	142	0		0
	143	1	3.54	93
	144	2	3.50	119
	145	3	3.27	204
	146	4	3.25	312
	147	5	3.25	436
	148	6	3.25	573
	149	7	3.25	722
Passing Flow	150	①	.81	546
	151	②	.81	772
	151.7	(1.7)	.81	897

King and Brater; Fig. 5-22

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PAGE 15 OF 32
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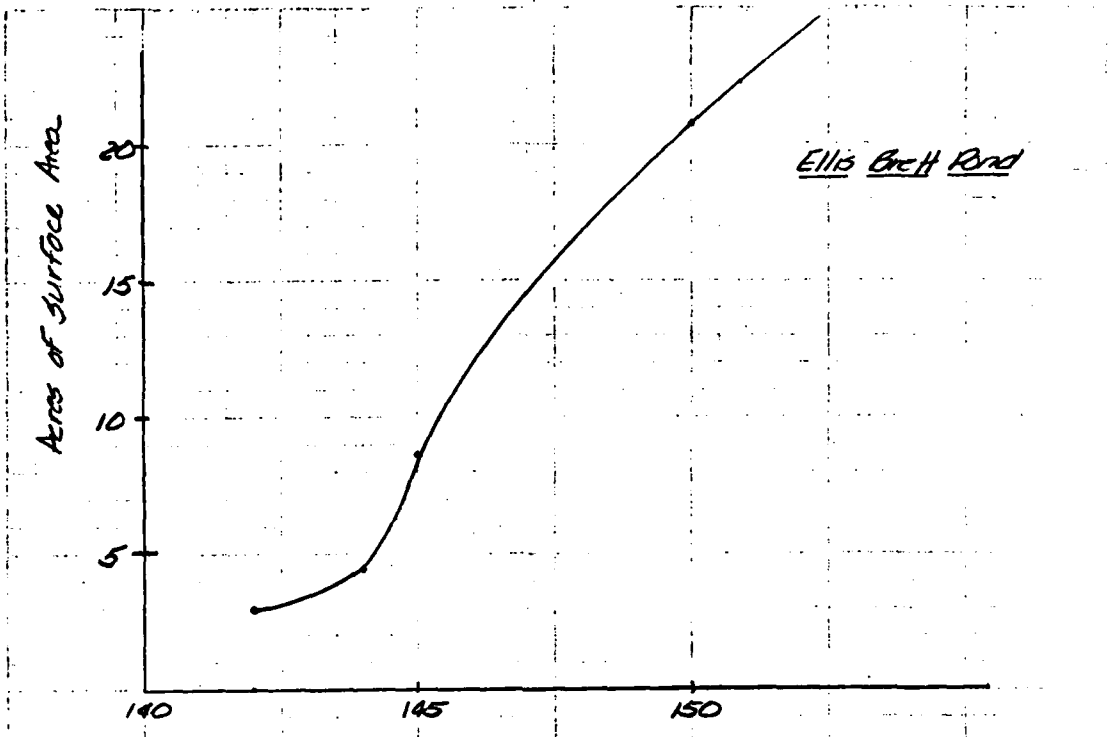


Generalized Estimate of Reservoir Outflows
Fair and Geyer, pg 207

Ratio of Storage Above Spillway Level to Flood Flow

$$\text{Flood Flow} = \frac{4190}{5006} \times 22{,}314{,}240 \text{ ft}^3 = 18{,}454{,}046 \text{ ft}^3$$

$$\text{Storage Above Spillway Level to Flood Flow} = \left(\frac{3^{ft} + 23.6^{ft}}{2}\right) 9.7 \text{ Ft} \times 43560 \frac{ft^2}{A} = 5{,}619{,}676 \text{ ft}^3$$

$$\text{Ratio} = \frac{5{,}619{,}676 \text{ ft}^3}{18{,}454{,}046 \text{ ft}^3} = .305$$

∴ Ratio of PMF outflow = 0.86 to PMF Inflow

PMF Outflow from Ellis Brett Pond = 4140 cfs × 0.86 = 3560 cfs

APPENDIX D-16

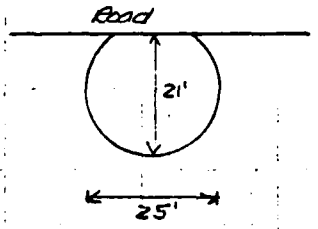
Sheet Flooding of Approximately 5 -one family dwellings, one apartment building, and several unattached structures (most likely automobile garages).

Cross Pond

Outlet Works

Circular Weir: Elev. 132.5 ft.
Top of Road: Elev. 134.8 ft.

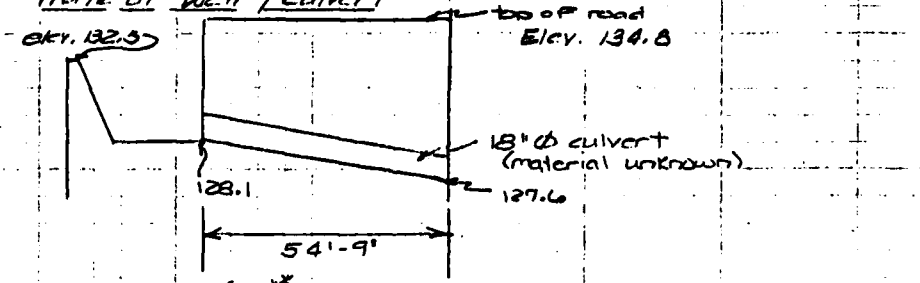
Plan View of Weir



Length = $\pi \times 25 - \frac{12.5 \times 99.3}{180}\ \pi$

= 18.45 π ≈ 58 feet

Profile of Weir / Culvert



Elev. W.S.	"C"* Value	Q
132.5		0
133.0	2.77	57
134.0	3.51	374
134.8	3.51	710
135.0	3.51	805

* King & Brater, Figure 5-9; Vertical upstream, 2:1 slope downstream face.

overland flow (290' length) = 645 cfs

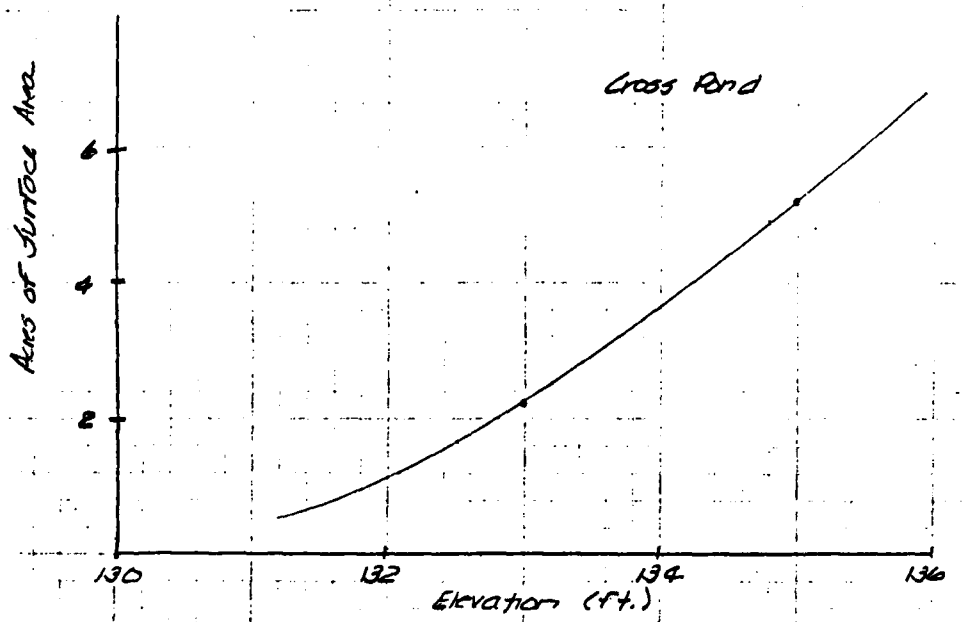
Culvert Capacity

Elev. W.S.	"C" Value	Q (cfs)
134.8 (5.7)	0.67	23
135.0 (5.9)	0.67	23

Area of Culvert:

$\frac{\pi (1.5)^2}{4} = 1.77\ \phi$

Assume concrete pipe



Generalized Estimate of Reservoir Outflows
Fair and Geyer, pg. 207

Ratio of Storage Above Spillway Level to Flood Flow

Flood Flow $= \left(\frac{3560}{5006}\right) \times 22,314,240\ ft^3 = 15,868,696\ ft^3$

Storage Above Spillway Level to Flood Flow: $\left(\frac{4.7 + 4.9}{2}\right) 2.3\ Ft. \times 43,560\ \frac{Ft^2}{Acre}$

$\cong 328,116\ ft^3$

CAMP DRESSER & McKEE INC. CLIENT USAE JOB NO. 290-5-16a PAGE 18 OF 32
PROJECT Winton Lake DATE CHECKED 6-8-79 DATE 11/29/79
DETAIL Hydraulics / Hydrology CHECKED BY [illegible] COMPUTED BY [illegible]

Storage = 328,116 ft³

Ratio = $\frac{328,116}{15,868,620}$ = .0207

∴ Ratio of Peak Inflow to Peak Outflow = 0.995

Peak Outflow from Cross Road = 0.995 x 3560 = 3540 cfs

This flow would cause severe flooding throughout the southern boundary of Cross Road (adjacent to Pleasant St.) flooding of the intersection of Prospect and Pleasant St, Wheeler Ave., Moraine, Ash, and Belmont Streets

CAMP DRESSER & McKEE INC. CLIENT COE/NOT JOB NO 380-5-15 PAGE 7 of 29
PROJECT Thirtyacre Pond DATE CHECKED 8 2879 DATE 2/23/79
DETAIL Hydraulics/Hydrology CHECKED BY [illegible] COMPUTED BY dlbd

Computation of Test Flood

Drainage Area to Brockton Reservoir = 1850 A

a. Times of Travel, Concentration, Lag

Overland : 4250 ft.
Beaver Brook : 8900 ft.
Total Length : 13,150 ft.

Average Slope:

15%	205'	~1,970
85%	260'	~11,180

$$\text{SLOPE} = \frac{55}{9210} = .00597 \approx .59718\ \%$$

Curve No. Analysis : Soil Group C

Land Use	Area	CN	CN x Area
Surface Water	86A	100	8600
Paved Roads	65A	98	6370
Wetlands	270A	98	26460
Wooded Areas	1429A	70	100030
	1850A		141460

Weighted CN = 76.5 , S = 3.072

$$L = \frac{(13,150)^{0.8}\,(3.072+1)^{0.7}}{1900\,(.59718)^{0.5}}$$

L = 3.59 hours ; say 3.60 hours

$$T_C = \frac{3.60}{0.6} = 6 \text{ hours}$$

b. Test Flood = PMF for 6 hours

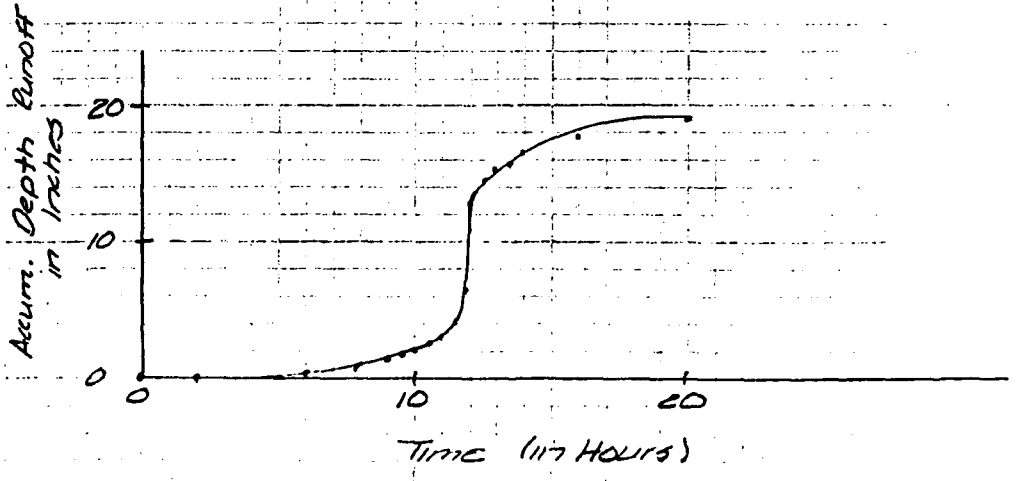
P = 24 inches in 6 hours

CAMP DRESSER & McKEE INC. CLIENT COE / NDOT JOB NO 380-5-15 PAGE 8 of 29
PROJECT Thirtyacre Road DATE CHECKED 4-2-79 DATE 2/23/79
DETAIL Hydraulics / Hydrology CHECKED BY [illegible] COMPUTED BY dlbd

c. $\Delta D = 0.4\,L$
$= (0.4)(3.60) = 1.44$ hours

$T\Delta D \simeq 10$ hours

Time (hours)	P_t/P_{24}	Mass P (inches)	Mass D (inches)
0.0	0	0	0
2.0	.022	.53	.002
6.0	.080	1.92	.390
8.0	.120	2.88	.962
9.0	.147	3.53	1.420
9.5	.163	3.91	1.706
10.0	.181	4.34	2.042
10.5	.204	4.90	2.500
11.0	.235	5.64	3.119
11.5	.283	6.79	4.124
11.75	.387	9.29	6.407
12.0	.663	15.91	12.737
12.5	.735	17.64	14.423
13.0	.772	18.53	15.293
13.5	.799	19.18	15.930
14.0	.820	19.68	16.420
16.0	.880	21.12	17.834
20.0	.952	22.85	19.536



CAMP DRESSER & McKEE INC. CLIENT COE/NDI JOB NO 380-5-15 PAGE 9 of 29
PROJECT Thirtyacre Road DATE CHECKED 4-20-79 DATE 2/23/79
DETAIL Hydraulics/Hydrology CHECKED BY [illegible] COMPUTED BY dlbd

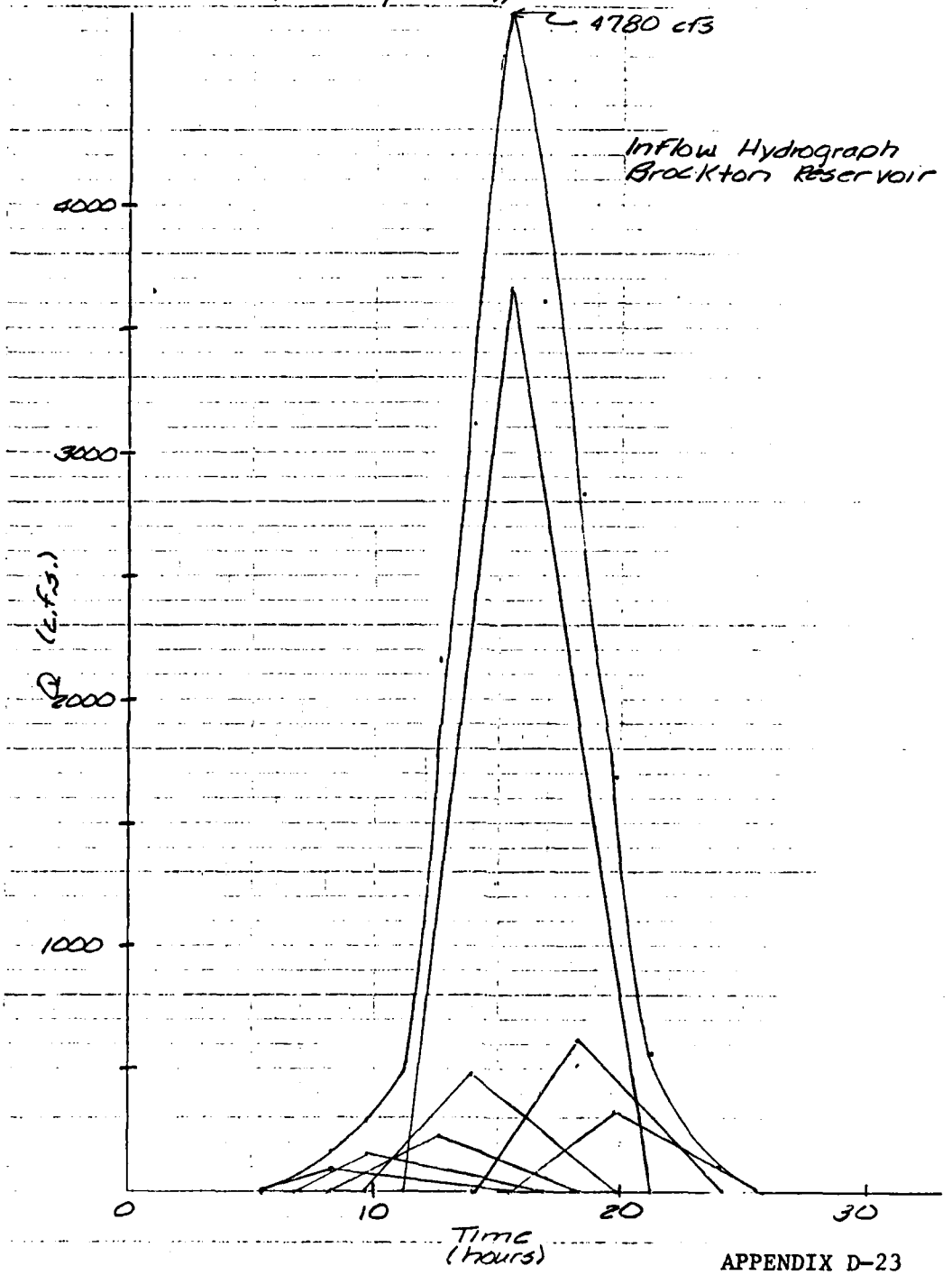
Start of Storm: 11.88 - 4.5(1.44) - 5.4 hours

Increment	Time (hours)	Mass Runoff (inches)	ΔQ (inches)	Δq (cfs)	Y	YΔq (cfs)
	5.40	.330				
ΔQ_1			.300	97	0.2	19
	6.84	.630				
ΔQ_2			.960	149	0.4	60
	8.28	1.090				
ΔQ_3			.690	223	0.6	134
	9.72	1.780				
ΔQ_4			1.500	486	0.8	390
	11.16	3.280				
ΔQ_5			11.317	36664	1.0	36664
	12.60	14.597				
ΔQ_6			1.880	609	0.667	406
	14.04	16.477				
ΔQ_7			0.989	320	0.333	107
	15.48	17.466				

4780 cfs

$$\Delta q_p = \frac{484 \times (2.89)}{\frac{1.44}{2} + 3.60} \Delta Q \approx 324 \Delta Q$$

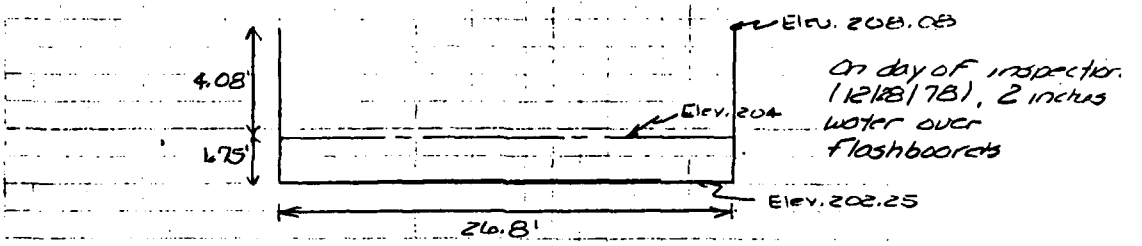
CAMP DRESSER & McKEE INC. CLIENT COE/NDOT JOB NO 380-5-15 PAGE 10 of 29
PROJECT Thirtyacre Pond DATE CHECKED 4/20/79 DATE 2/23/79
DETAIL Hydraulics/Hydrology CHECKED BY [illegible] COMPUTED BY dlbd



APPENDIX D-23

CAMP DRESSER & McKEE INC. CLIENT COE / NDI JOB NO 380-5-15 PAGE ~~1 of 29~~
PROJECT Thirtyacre Pond DATE CHECKED 8-20-79 DATE 2/23/79
DETAIL Hydraulics / Hydrology CHECKED BY CMiller COMPUTED BY dlbd

Brockton Reservoir Outlet



Spillway Rating Curve

Sharp crested weir: L/b = 1.0
H = height water over weir
P = dist. from weir crest to weir base (vertical)

P = 1'9" (1.75')

Head (Ft.)	H/p	C (value)	Q*
0	0		0
1	.57	3.47	93
2	1.14	3.68	279
3	1.71	3.90	543
4	2.29	4.00	858
4.08	2.33	4.00	883

* with 1.75 Ft. of Flashboards installed.

Note: Top of Dam elevation = 208.08

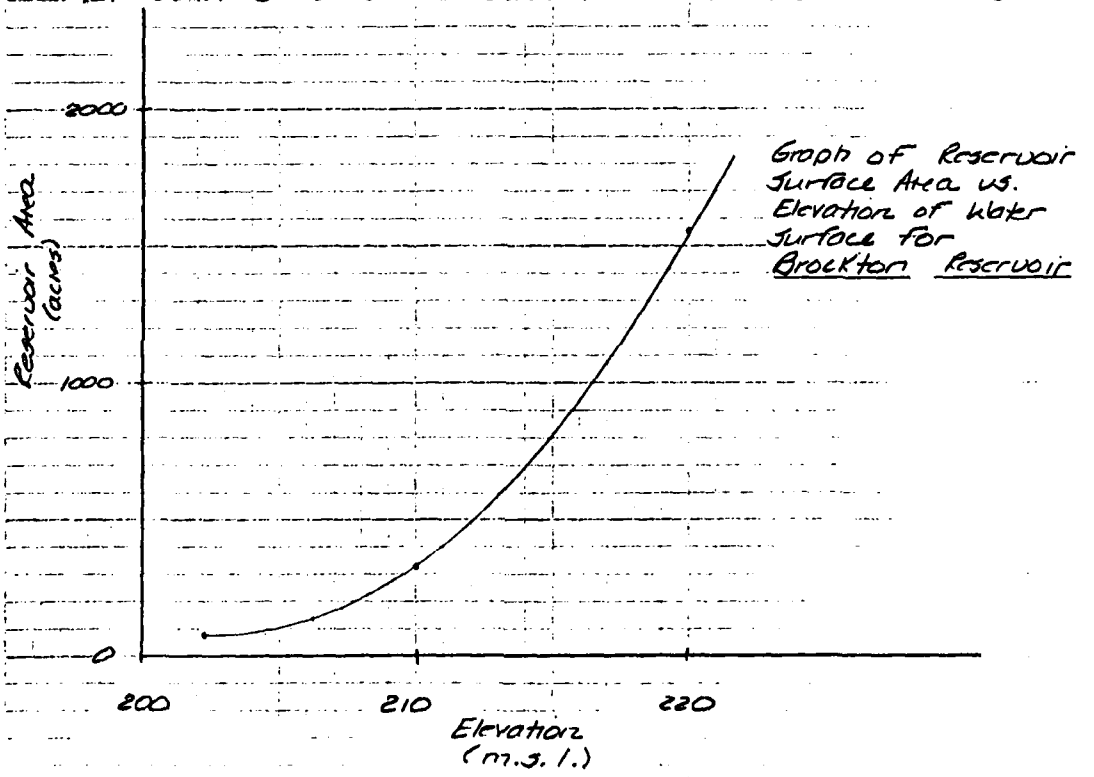
Head (Ft.)	H/p	C (value)	Q*
0		4.00	0
1			107
2			303
3			557
4			858
5			1199
5.83			1509
6			1576 + 263 = 1839
7			1985 + 4746 = 6731

* no Flashboards in place P = 0

overland flow

CAMP DRESSER & McKEE INC. CLIENT COE / NAE JOB NO 390-5-15 PAGE ~~12 of 29~~
PROJECT Thirtyacre Pond DATE CHECKED ~~2-26-79~~ DATE 2/26/79
DETAIL Hydraulics / Hydrology CHECKED BY ~~Miller~~ COMPUTED BY dlbd

Head on Spillway	Elev. of W.S.	Res. Area (acres)	Calc. Outflow (cfs)	Calc. Storage (acre-ft)	$\frac{S}{\Delta t}$* (cfs)	$\frac{S}{\Delta t} - \frac{O}{2}$ (cfs)	$\frac{S}{\Delta t} + \frac{O}{2}$ (cfs)
0	202.25	87	0	0	0	0	0
1	203.25	90	107	89	1077	1024	1131
2	204.25	95	303	181	2190	2038	2341
3	205.25	105	557	281	3400	3122	3679
4	206.25	135	858	401	4852	4423	5281
5	207.25	175	1199	556	6728	6120	7327
5.83	208.08	210	1509	716	8661	7906	9415
6	208.25	215	1839	751	9087	8167	10006
7	209.25	275	6731	996	12052	8687	15418

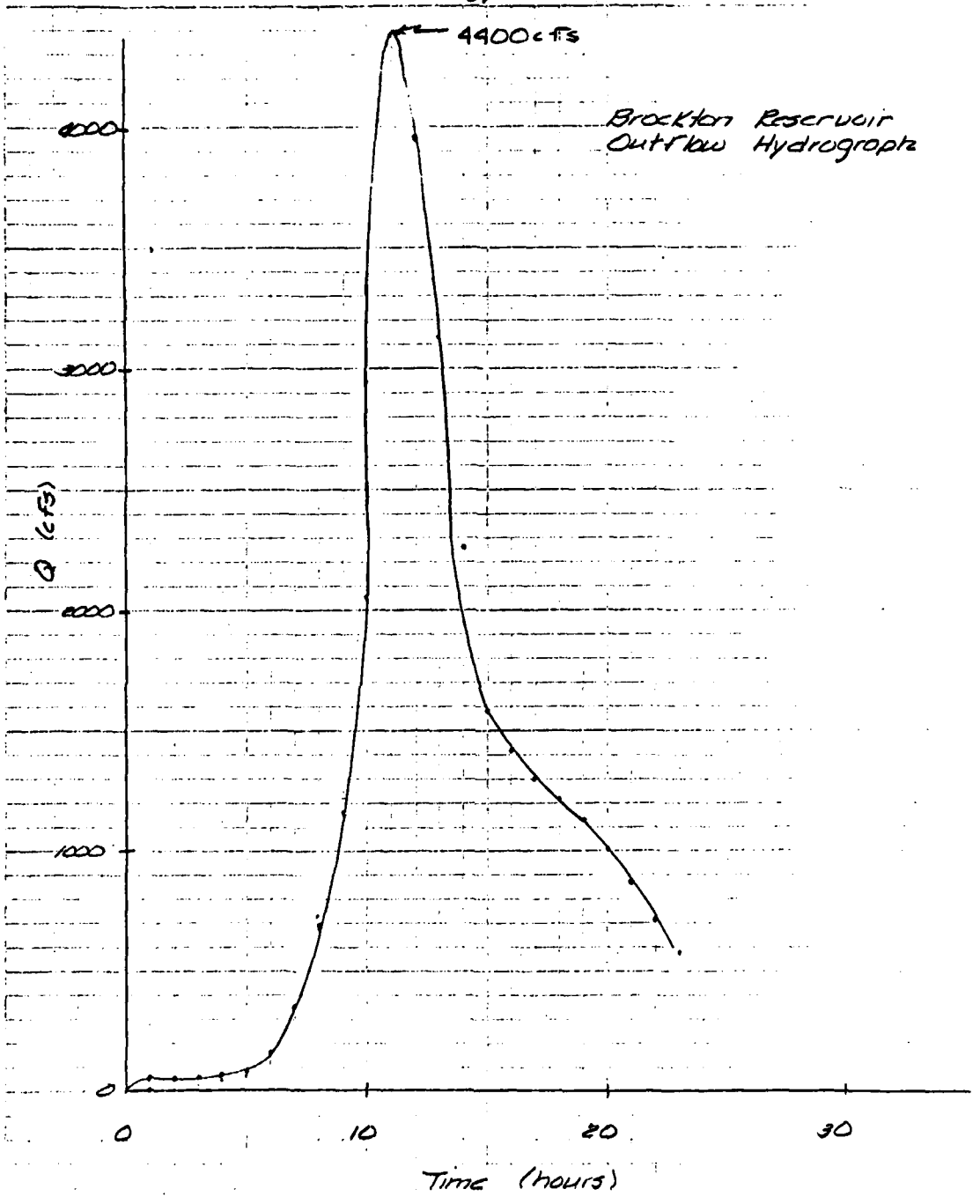


CAMP DRESSER & McKEE INC. CLIENT COE LRNOT JOB NO 280-5-15 PAGE ~~13 of 29~~
PROJECT Thirtyacre Road DATE CHECKED 4-27-79 DATE 8/26/79
DETAIL Hydraulics/Hydrology CHECKED BY [illegible] COMPUTED BY dlbd

Calculations of Brocktan Reservoir Outflows

Time No.	Obs Inflow (cfs)	Aver. Inflow (cfs)	$\frac{S}{\Delta t} - \frac{Q}{2}$	$\frac{S}{\Delta t} + \frac{Q}{2}$	Head on Spillway (ft.)	Elev. of Wat. Surf. (ft.)	Outflow Q (cfs)
0	0	0	—			202.25	0
1	45	22	—	—	0.42	202.67	45
2	105	75	431	506	0.45	202.70	48
3	180	143	458	601	0.53	202.78	57
4	270	225	544	769	0.68	202.93	73
5	380	325	696	1021	0.90	203.15	97
6	525	552	925	1477	1.29	203.54	163
7	1700	1213	1314	2527	2.14	204.39	338
8	2750	2225	2189	4414	3.96	205.71	695
9	3960	3355	3719	7074	4.88	207.13	1157
10	4780	4370	5917	10227	6.04	208.29	2037
11	4250	4515	8188	12703	6.50	208.77	4277
12	3550	3900	8426	12326	6.93	208.68	3946
13	2590	3045	8290	11435	6.26	208.51	3131
14	1800	2170	8304	10474	6.09	208.34	2262
15	900	1350	8212	9562	5.87	208.12	1591
16	460	680	7971	8651	5.57	207.82	1411
17	280	370	7944	7814	5.28	207.53	1303
18	160	220	6938	7158	5.05	207.30	1219
19	60	110	6542	6652	4.79	207.04	1129
20	0	30	6034	6064	4.45	206.70	1013
21	0	0	5343	5343	4.04	206.29	870
22	0	0	4996	4996	3.51	205.76	711
23	0	0	3785	3785	3.07	205.32	577

CAMP DRESSER & McKEE INC. CLIENT COE NAO T JOB NO 330-5-15 PAGE 14 of 27
PROJECT Thirtyacre Pond DATE CHECKED 6-20-79 DATE 5/23/79
DETAIL Hydraulics/Hydrology CHECKED BY Chesler COMPUTED BY dlbd



APPENDIX D-27

CAMP DRESSER & MCKEE INC. CLIENT COE/IIDOT JOB NO 380-5-15 PAGE ~~45 of 89~~
PROJECT Thirtyacre Pond DATE CHECKED 6-20-79 DATE 2/23/79
DETAIL Hydraulics/Hydrology CHECKED BY [illegible] COMPUTED BY dlbd

Waldo Lake Inflow

Additional Drainage Area = 228 Acres

1) Peak Flow Determination from 228 Acres

$$\frac{Q_1}{Q_2} = \frac{A_1^{\left(\frac{.896}{A_1^{.896}} - 1\right)}}{A_2^{\left(\frac{.896}{A_2^{.896}} - 1\right)}}$$

$Q_1 = 4400 \text{ cfs} / 2.89 \text{ sq. mi.} = 1522 \text{ CSM}$

$A_1 = 2.89$ sq. mi.

$A_2 = 0.36$ sq. mi.

$$\therefore Q_2 = \frac{1522 \text{ CSM}}{\frac{2.89^{-.15}}{.36^{-.061}}} \cdot 1900 \text{ CSM}$$

$Q_2 = 684$ cfs

2) Find T_p

Length = 1800 ft
Slope = 0.030
Velocity = .43 ft/s (SCS - Section 4 - Figure 15.2)

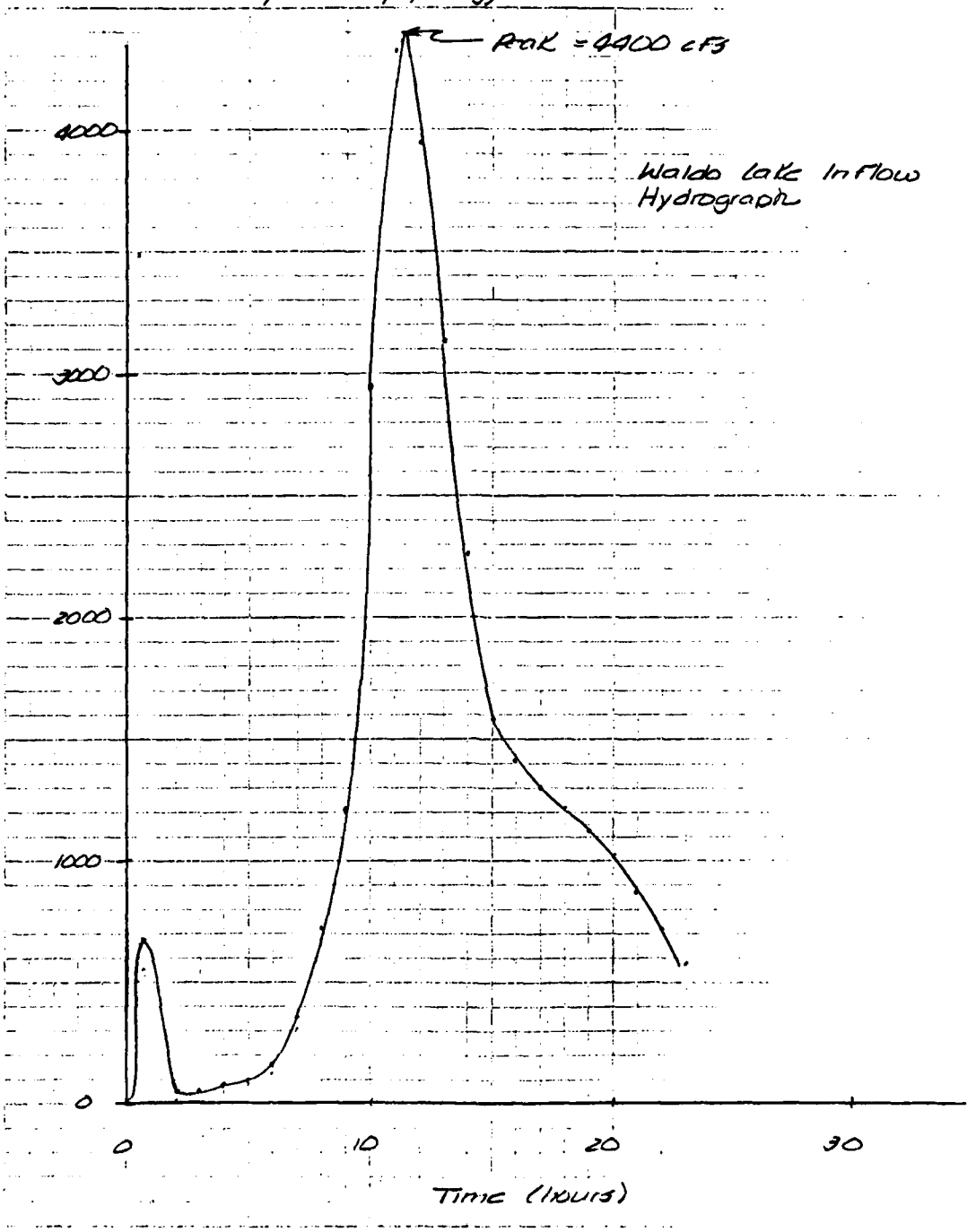
$T_c = 1800 / 0.43 = 4186$ sec $= 1.16$ hours

Lag $= 0.6\ T_c = 0.70$ hours
$\Delta D = 0.4\ L = 0.4 \times 1.70 = 0.28$ hours

$\therefore T_p = \frac{.28}{2} + 0.70 = 0.84$ hours

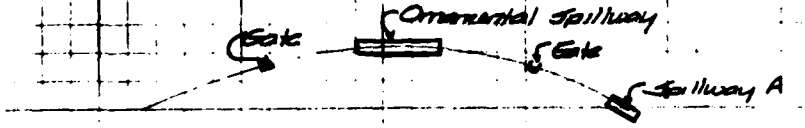
Resulting Inflow Hydrograph into Waldo Lake is on following page.

CAMP DRESSER & McKEE INC. CLIENT COE/UDOT JOB NO 180-5-15 PAGE 46 of 89
PROJECT Thirdyacre Road DATE CHECKED 4-20-79 DATE 2/23/79
DETAIL Hydraulics/Hydrology CHECKED BY Offsider COMPUTED BY dlbd

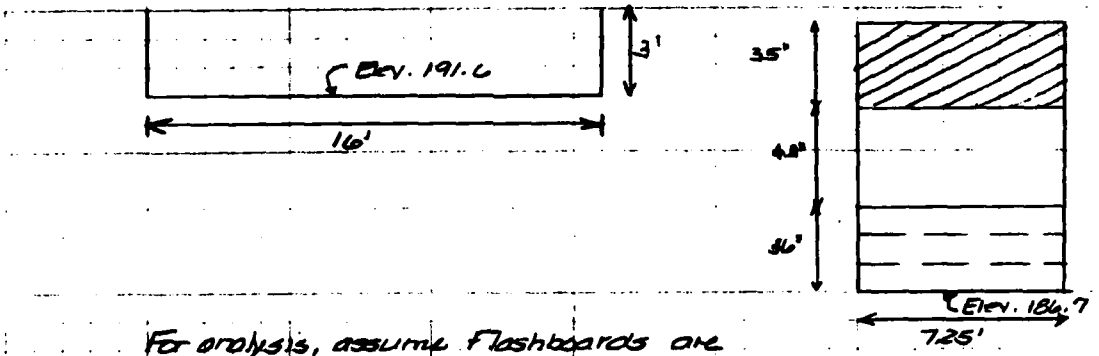


APPENDIX D-29

Waldo Lake Outlet Structures



Ornamental Spillway (O.S.)



For analysis, assume Flashboards are removed.

	Elevation W.S.	L_A (S-23)	Q_A	L_{OS} (S-22)	Q_{OS}	Q_{TOTAL}	
	184.7	—	0	—	—	0	
	187	3.13	4	—	—	4	
	188	3.11	33	—	—	33	
	189	3.17	80	—	—	80	
	190	3.29	143	—	—	143	
	191	3.37	218	—	—	218	
	191.6	3.37	265	—	—	265	
	193	3.37	386	3.55	94	480	
	193.3	3.37	414	3.53	125	539	
	194.6	0.81	356	3.27	272	628	
Pressure Flow	196.0	0.82					746
	197.0						781
	197.5						798
	198.0						814
	200.0						877

Dike and Dam Overland Flow Calculations

Dike :

Length = 290 ft.
Crest Elevation = 196.1 ft
Overland Flow : C = 2.5

Dam :

Length = 400 ft.
Crest Elevation = 197.5 ft.
Overland Flow : C = 2.5

Elevation W.S.	Q_{DIKE}	Q_{DAM}	Q_{TOTAL}
196.1	0	0	0
197.0	619	0	619
197.5	1201	0	1201
198.0	1900	354	2254
200.0	3584	3953	9597

Rating Table for Outlet Structures

Elevation W.S.	Q_{TOTAL}
186.7	0
187	6
188	33
189	80
190	143
191	218
191.6	265
193	480
193.3	539
194.6	628
196.0	746
197	1400
197.5	1999
198.0	9068
200.0	10414

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CLIENT COE / NDOT
PROJECT Waldo Lake Dam
DETAIL Hydraulics / Hydrology

JOB NO 330-5-11a
DATE CHECKED 6-8-79
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PAGE 298 of 32
DATE 5/7/79
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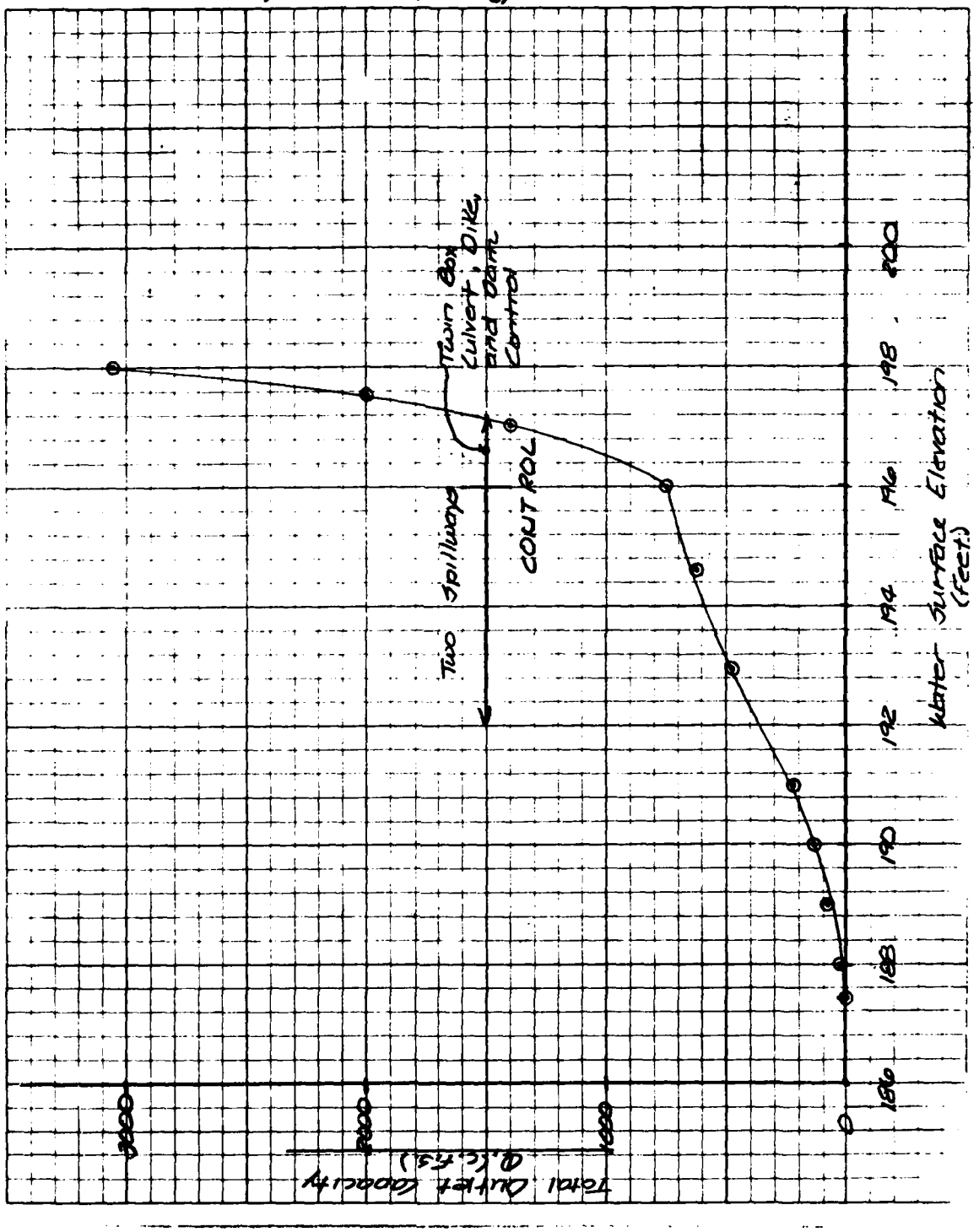

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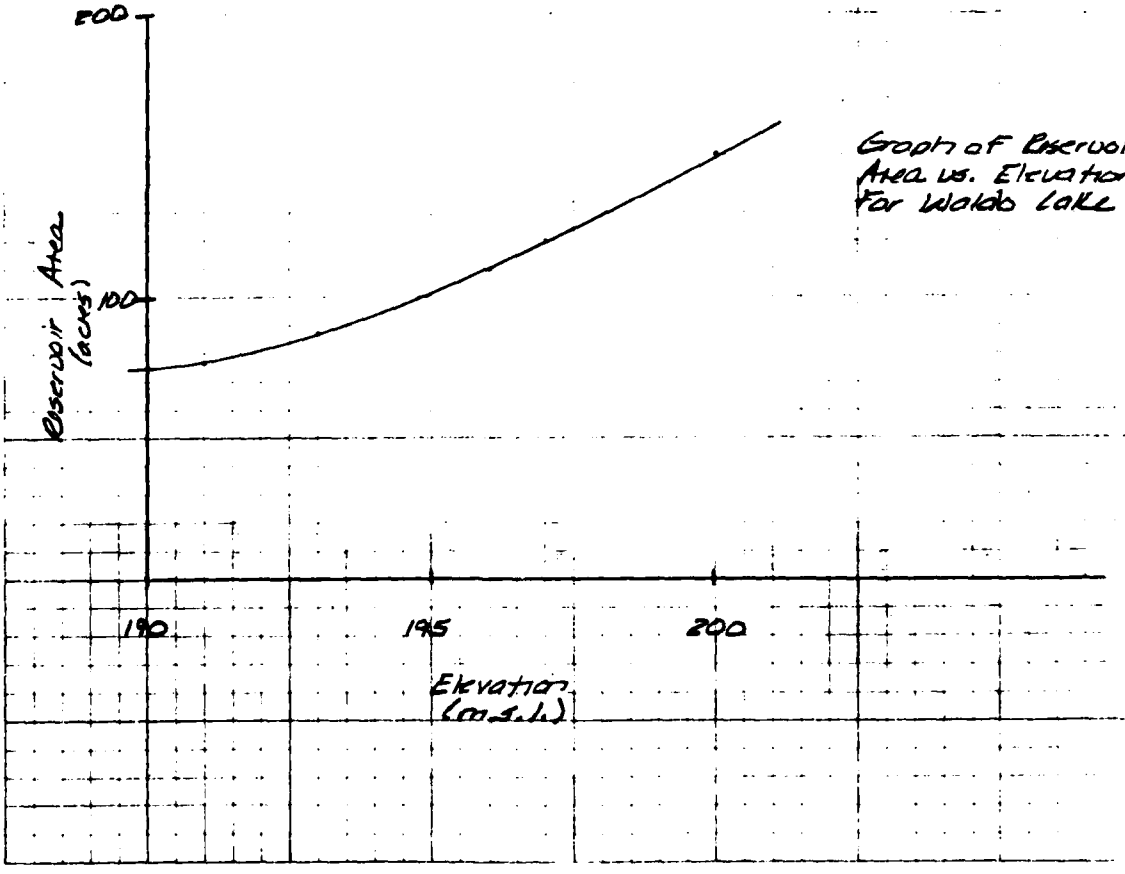
DETAIL Hydraulics / Hydrology

JOB NO 380-5-15
DATE CHECKED 6-5-79
CHECKED BY [illegible]

PAGE 30 of 32
DATE 6/5/79
COMPUTED BY dlbd

Elevation W.S.	Reservoir Area (acres)	Calc. Outflow (cfs)	Calc. S (acre-ft)	$\frac{S}{\Delta t}$ (cfs)	$\frac{S}{\Delta t} - \frac{Q}{2}$ (cfs)	$\frac{S}{\Delta t} + \frac{Q}{2}$ (cfs)
186.7	70	0	0	0		
188	70.5	33	91	1101	1085	1118
189	72	80	162	1960	1920	2000
190	74	143	235	2844	2773	2916
191	78	218	311	3763	3654	3872
193	87	480	476	5760	5520	6000
194.6	98	628	624	7550	7236	7864
196.0	110	746	770	9317	8944	9690
197.0	118	1400	884	10696	9996	11396
197.5	126	1999	945	11435	10435	12434
198.0	128	3068	1008	12197	10663	13731
200.0	150	10414	1286	15567	10360	20774



Graph of Reservoir Area vs. Elevation for Waldo Lake

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PROJECT Thirty Acre - Waldo
DETAIL Hydraulics / Hydrology

JOB NO 380-5-15
DATE CHECKED 6-5-79
CHECKED BY [illegible]

PAGE 31 of 32
DATE 6/5/79
COMPUTED BY dlbd

Time No.	Obs. Inflow (cfs)	Avg Inflow (cfs)	$\frac{I}{\Delta t} - \frac{Q}{2}$ (cfs)	$\frac{I}{\Delta t} + \frac{Q}{2}$ (cfs)	Head (on Block) (ft.)	Elev. W.S. (ft.)	Q Outflow (cfs)
0	0	0					0
1	620	310			7.8	194.5	603
2	48	334	7143	7478	7.6	194.3	597
3	57	53	6881	6934	7.1	193.8	554
4	73	65	6380	6445	6.7	193.4	515
5	97	85	5930	6015	6.3	193.0	481
6	166	132	5534	5666	6.0	192.7	439
7	354	260	5227	5487	5.8	192.5	317
8	717	536	5070	5606	5.9	192.6	431
9	1220	969	5175	6144	6.4	193.1	491
10	2947	2082	5653	7735	7.8	194.5	618
11	4383	3664	7117	10781	9.9	196.6	1764
12	3946	4136	9617	13753	11.3	198.0	3091
13	3131	3537	10662	14199	11.4	198.1	3556
14	2262	2697	10643	13340	11.1	197.8	2746
15	1591	1927	10594	12521	10.8	197.5	2071
16	1411	1501	10450	11951	10.6	197.3	1720
17	1303	1357	10231	11588	10.4	197.1	1511
18	1419	1261	10072	11338	10.2	196.9	1378
19	1129	1174	9960	11134	10.1	196.8	1300
20	1013	1071	9834	10905	10.0	196.7	1212
21	870	942	9694	10636	9.9	196.6	1109
22	711	791	9527	10318	9.7	196.4	987
23	577	644	9331	9975	9.5	196.2	855

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PROJECT Thirty Acre - Waldo
DETAIL Hydraulics / Hydrology

JOB NO 390-5-15
DATE CHECKED 6-5-79
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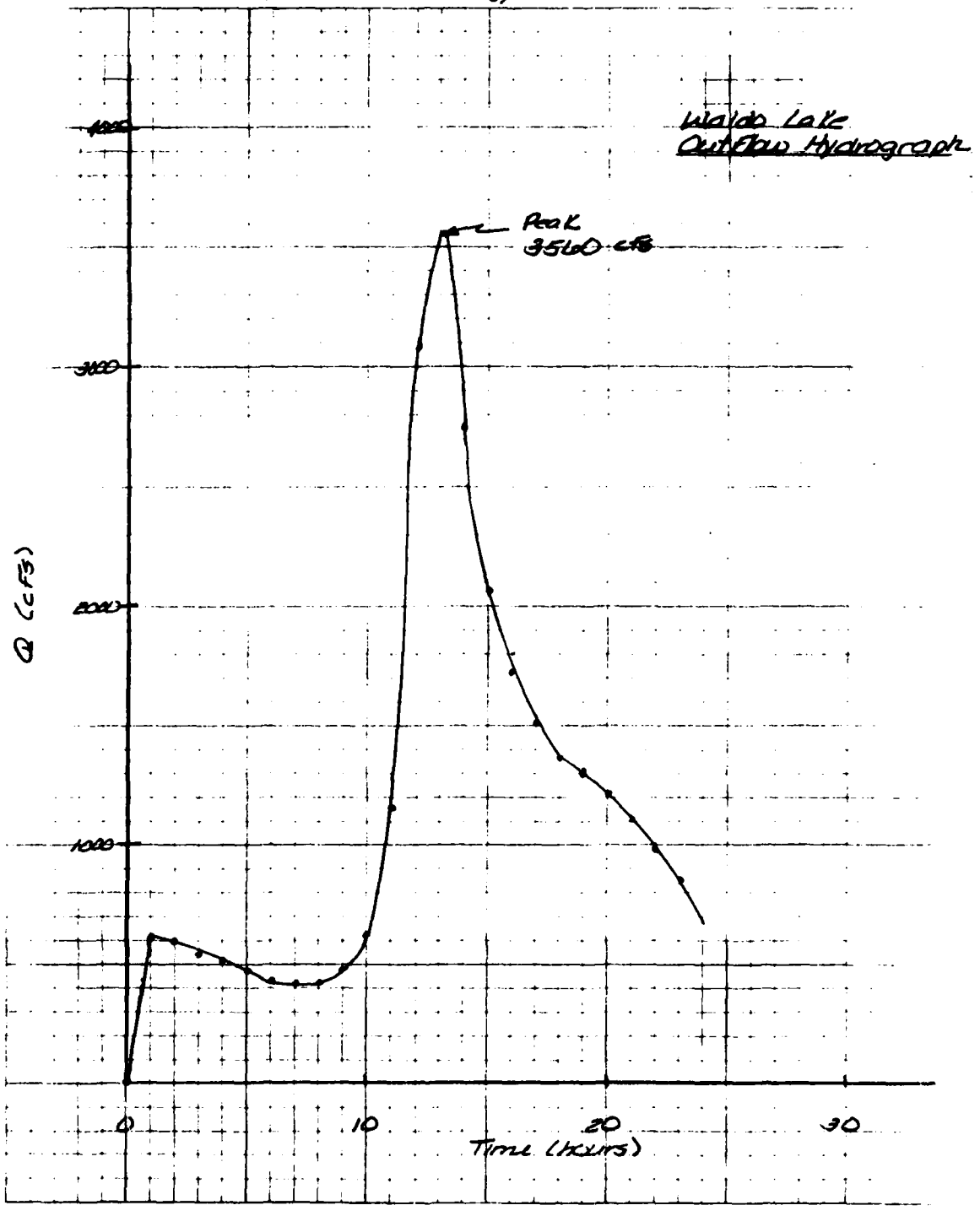
PAGE 32 of 32
DATE 6/5/79
COMPUTED BY dlbd



APPENDIX E
INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

(1) STATE	(2) IDENTIFICATION NUMBER	(3) DIVISION	(4) STATE	(5) COUNTY	(6) CONGR DIST	(7) STATE	(8) COUNTY	(9) CONGR DIST	(9) NAME	(10) LATITUDE (NORTH)	(11) LONGITUDE (WEST)	(12) REPORT DATE DAY | MO | YR
MA	420	NED	MA	023	11				WALDO LAKE DAM	4206.3	7102.9	22JUN79

(13) POPULAR NAME	(14) NAME OF IMPOUNDMENT
	WALDO LAKE

(15) REGION	(16) BASIN	(17) RIVER OR STREAM	(18) NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	(19) DIST FROM DAM (MI)	(20) POPULATION
01	06	BEAVER BROOK	BROCKTON	0	95000

(21) TYPE OF DAM	(22) YEAR COMPLETED	(23) PURPOSES	(24) STRUCTURAL HEIGHT (FT)	(25) HYDRAULIC HEIGHT (FT)	(26) IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT)	(26) IMPOUNDING CAPACITIES NORMAL (ACRE-FT)	(27) DIST	(28) OWN	(29) FED R	(30) FRV/FED	(31) SCS A	(32) VER/DATE
REPG	1936	R	17	17	644	227	NED	N	N	N	N	22JUN79

(33) REMARKS

(34) D/S HAS	(35) SPILLWAY LGTH (FT)	(35) SPILLWAY TYP	(35) SPILLWAY WIDTH (FT)	(36) MAXIMUM DISCHARGE (FT)	(37) VOLUME OF DAM (CY)	(38) POWER CAPACITY INSTALLED (MW)	(38) POWER CAPACITY PROPOSED (MW)	(39) NAVIGATION LOCKS NO	LENGTH (FT)	WIDTH (FT)	LENGTH (FT)	WIDTH (FT)	LENGTH (FT)	WIDTH (FT)	LENGTH (FT)	OTHER (FT)
1	400	C	7	798												

(40) OWNER	(41) ENGINEERING BY	(42) CONSTRUCTION BY
CITY OF BROCKTON		POWERS BROTHERS

(43) REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	NONE

(44) INSPECTION BY	(45) INSPECTION DATE DAY | MO | YR	(46) AUTHORITY FOR INSPECTION
CARD DRESSER AND MCKEE	040CT78	PL 92-367

(47) REMARKS
31-SPILLWAYS 32-ALSO 16 FOOT WIDE EMERGENCY SPILLWAY